HP 10016512-1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of :
Donald J. Fasen : Group Art Unit 2627
Serial No. 10/700,065 : Examiner: Goma, Tawfik A.
Filed: 11/03/2003 : Date: May 8, 2007
For: MEMORY :

AFFIDAVIT UNDER 37 C.F.R. 1.131

Commissioner of Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I hereby declare that I am the inventor of the invention entitled MEMORY, disclosed and claimed in the above-identified patent application.

Enclosed herewith is a copy of an invention disclosure, which shows that the invention was conceived by me on or before March 2, 2001. I continued to work diligently on the invention from the date of conception to my filing of a Patent Application on November 3, 2003 as evidenced by the attached documents:

	Date	Activity	Evidence by Documents
1	July 6, 2000	Working on Pattern Architectures	Pattern Architectures, see page 2
2	July – Dec. 2000	Working on invention	Pattern Architectures
3	December 1, 2000	Working on Servo Review document	ServoReview document showing the servo pattern per the properties page in the document
4	Jan. – May 10, 2001	Working on Servo Code Pattern	Pattern Servo Code in MEMs Device
5	May 11, 2001	Working on invention	Invention Disclosure
6	July 25, 2001		Email from HP to inventor acknowledging submission of invention disclosure
7	July 25, 2001		Letter to Outside Counsel to prepare and file a patent application

8	July 24, 2002		Letter to outside counsel re transfer of file from Boise to Ft. Collins
9	November 2002		Servo System Review Powerpoint Presentation
10	February 18, 2003		Email from outside counsel verifying inventor info
11	March 10, 2003	Working on Servo Pattern Feasibility	Servo Pattern Feasibility Study
12	October 27, 2003	Working on Pattern Sensing	Pattern Sensing document
13	October 27, 2003	Receipt, execution and return of formal papers to outside counsel	Formal papers signed by inventor

My conception and work on the invention occurred in the United States of America.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of Inventor: Donald J. Fasen
Address: 12129 W. Musket, Boise, ID 83713
Citizenship: US

Donald J. Fasen   5/9/2007

Donald J. Fasen   Date

Pattern Architectures

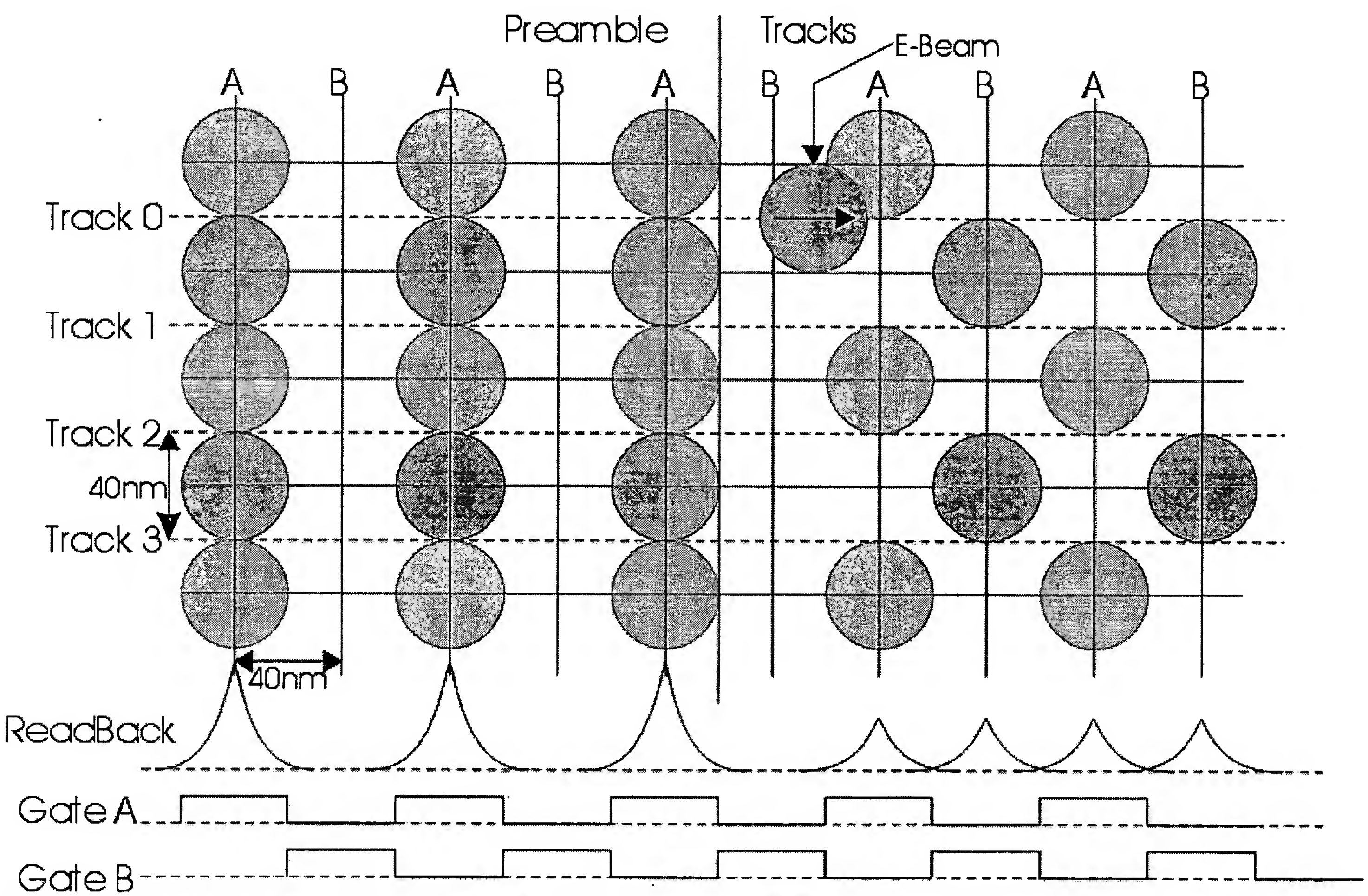
Updated: Wednesday, 09-May-2001 11:27:45 MDT

Pattern Layout

4/6/01

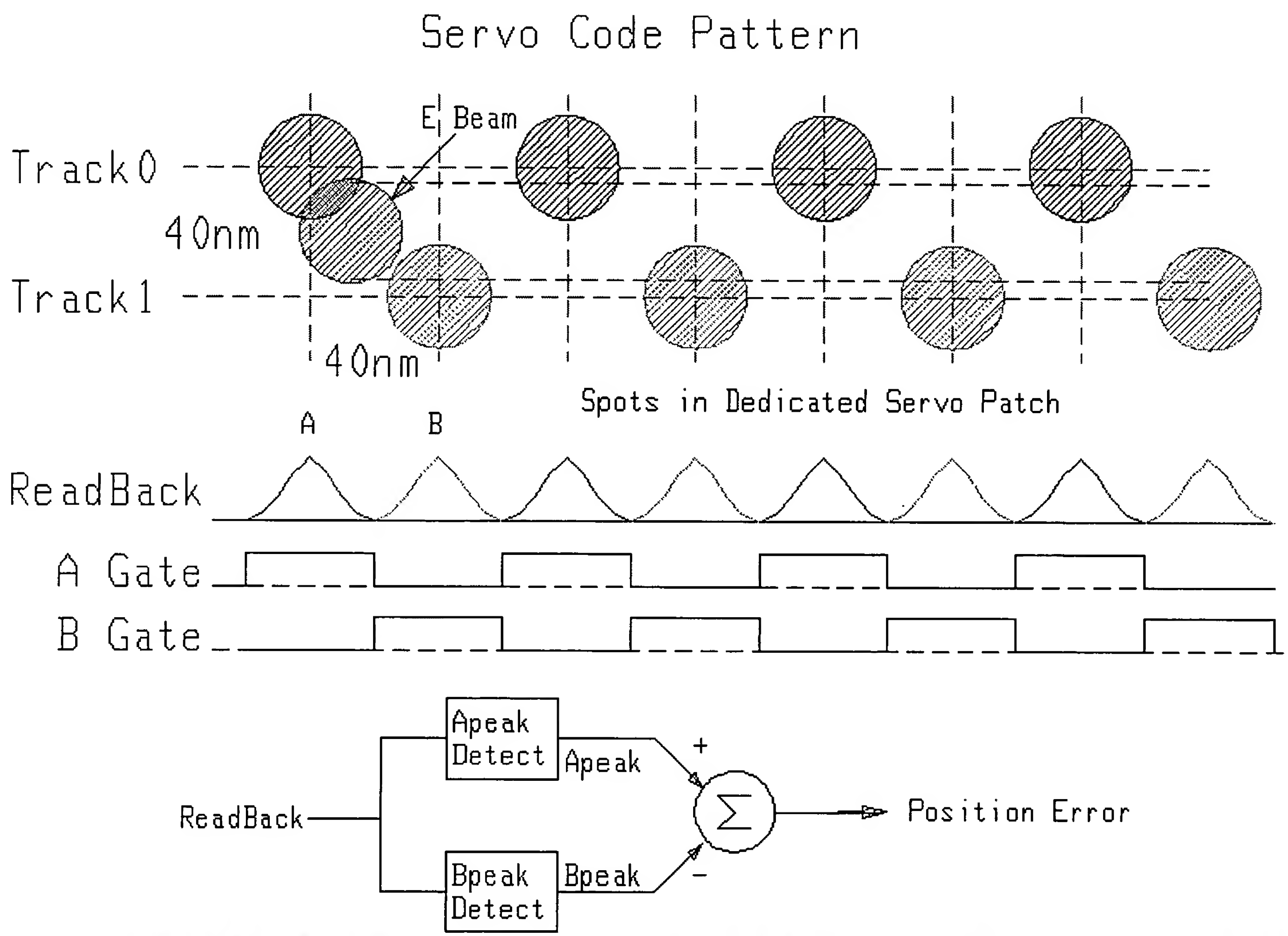
The preamble is an all "A" field pattern to allow timing acquisition with the correct phase so that A and B gates can be generated in the track area.

Servo Code Pattern



Continuous Servo

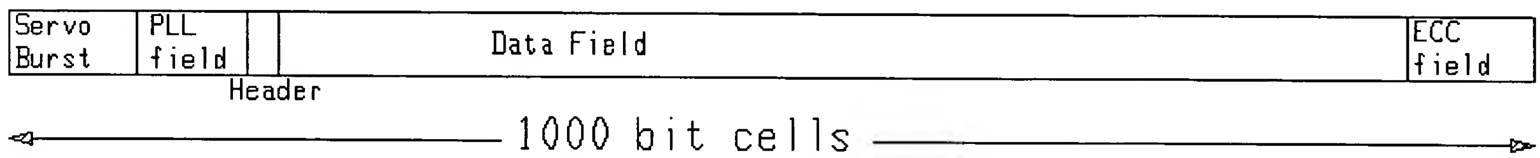
7/6/00
Continuous (dedicated) servo code in the 4 corner patches is attractive because this would allow a closed loop positioning throughout the track sweep. Two of the corner patch signals would be demodulated simultaneously to allow for correction/detection of torsional movement. The other 2 patches could be used for data once 2 good servo patchtips were found in manufacturing.
This approach could include both across track positioning and timing correction down the track.
The problem with this is how to get the signals from 4 addional servo clusters (the same outline as the servo patch) off of the translator. This would require 2 additional wires on each spring for a total of 10 wires.



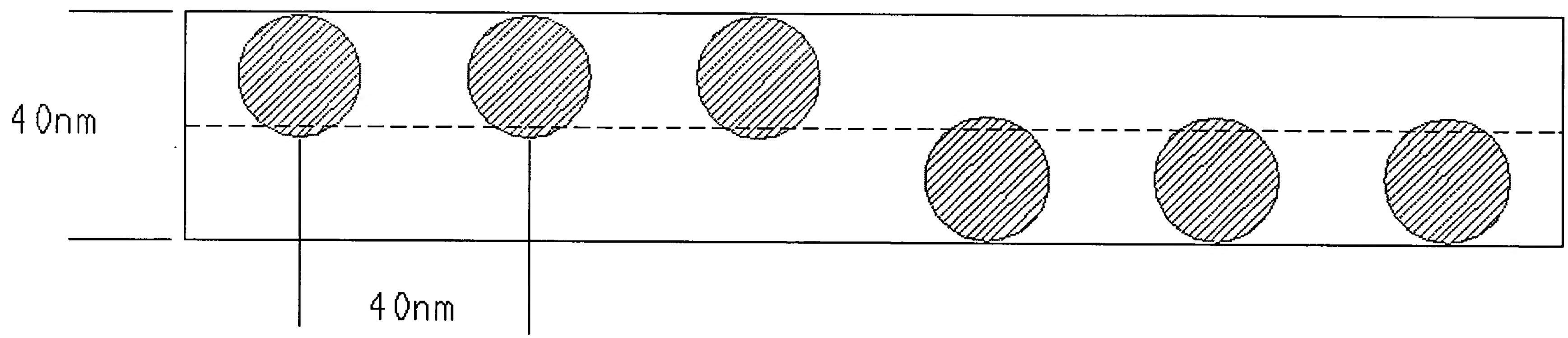
Burst Servo

One possibility is to use a servo burst at the beginning of each track. This allows the same 16 clusters (and traces off of the translator) to be used for the servo readback. The disadvantage is that only one correction is possible at the beginning of each track sweep. Also, the overhead is high (6/1000) compared to using 2 or 4 patches for a dedicated servo.

Track Layout



Servo Burst



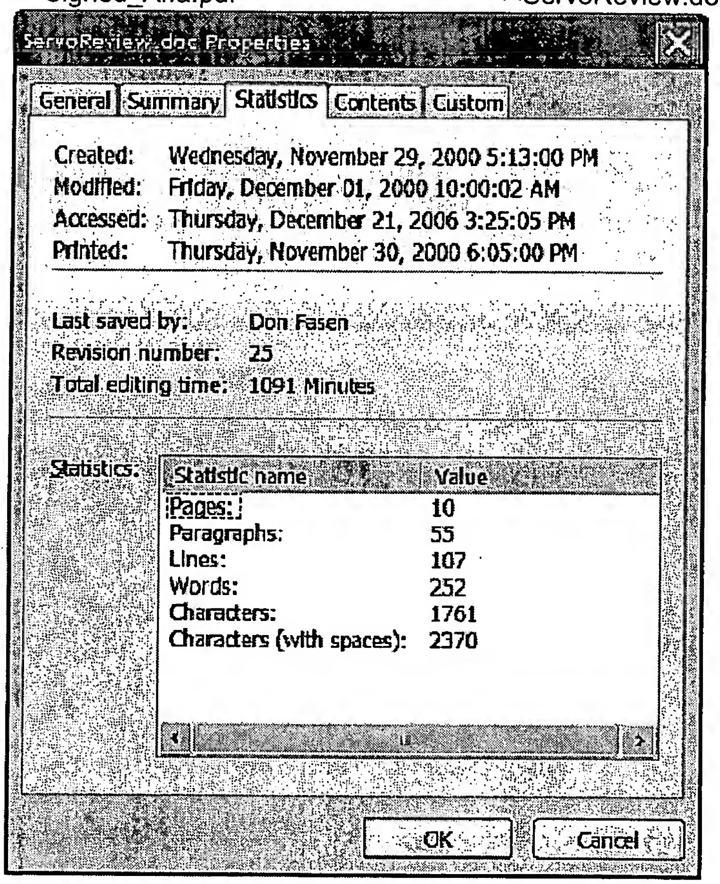
Leigh Christian

From: Fasen, Donald [don.fasen@hp.com]
Sent: Thursday, December 21, 2006 2:32 PM
To: Leigh Christian
Cc: wjjones@hightechlawyer.net; Homan, Lucy J
Subject: RE: 10016512-1

Leigh,
Attached is the signed affidavit.

The ServoReview document shows the servo pattern and is dated 12/01/2000 as per the properties page in the doc.

<<Signed_Affa.pdf>> <<ServoReview.doc>>



From: Leigh Christian [mailto:Leigh-C@pacbell.net]
Sent: Tuesday, December 19, 2006 12:56 PM
To: Fasen, Donald
Cc: wjjones@hightechlawyer.net; Homan, Lucy J
Subject: 10016512-1

Orca Servo System

- Requirements
- Function Blocks
- Off-track Budget
- Positioning Issues

Requirements

1) Resonance Stabilization
- 10kHz Electromechanical Resonance
- Requires always on, high bandwidth (50khz) servo loop x32 axis

2) Repeatable Positioning
- Across track (Mounting, Flexure variation, Vibration)
- Between Data Writes and Reads
- Diode Contact Search

3) Track Scan and Seek Motion Control
- Acceleration/Deceleration Profile (To avoid slipping and ringing)
- 2ms Track Scan Duration

4) Read/Write Timing
- Tracking Clock
- Track Scan velocity control

Funct on Blocks

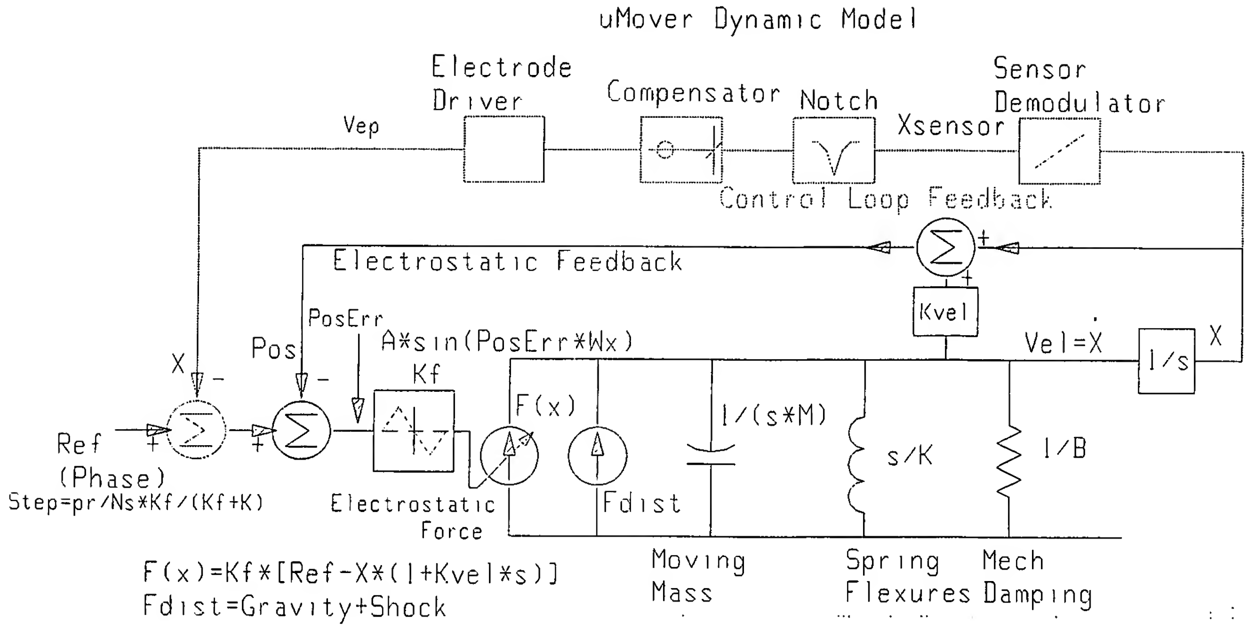
1) Actuator (micro-mover)
- **Nrotor=6, Nstator=7 with Proportional Electrode Voltage for 40nm sub-phase.**

2) Position Sensors
- **Servo Code**
- **Capacitive Sensors (Electrode and Coupling Block)**

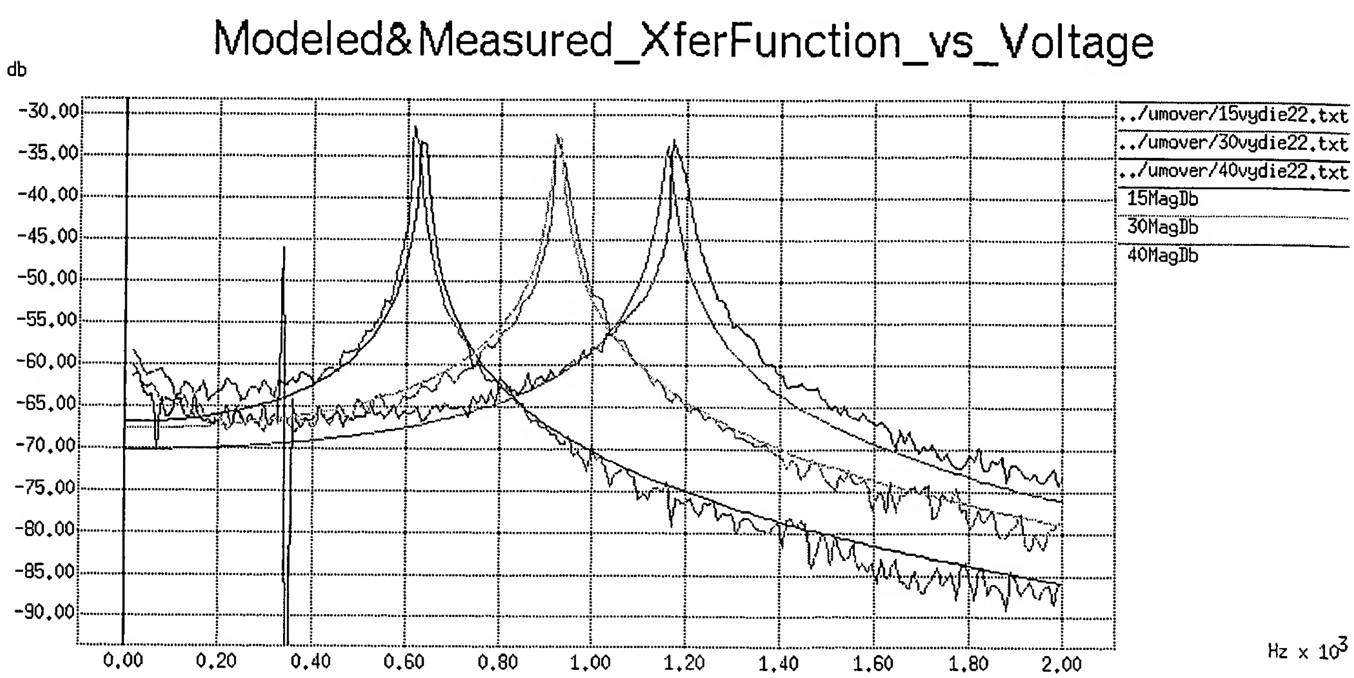
3) Control and Compensation
- **Hardwired DSP (bit serial)**

4) Electrode Driver
- **RAM table for Accel/Decel Profile**
- **Hardware Phase Advance/ DAC step**

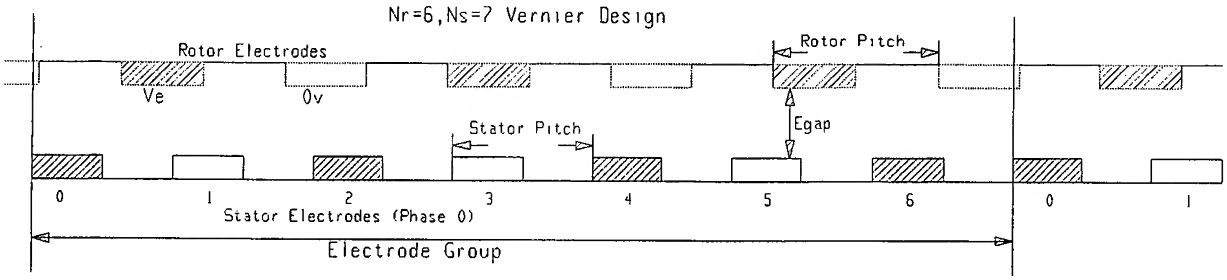
Block Diagram



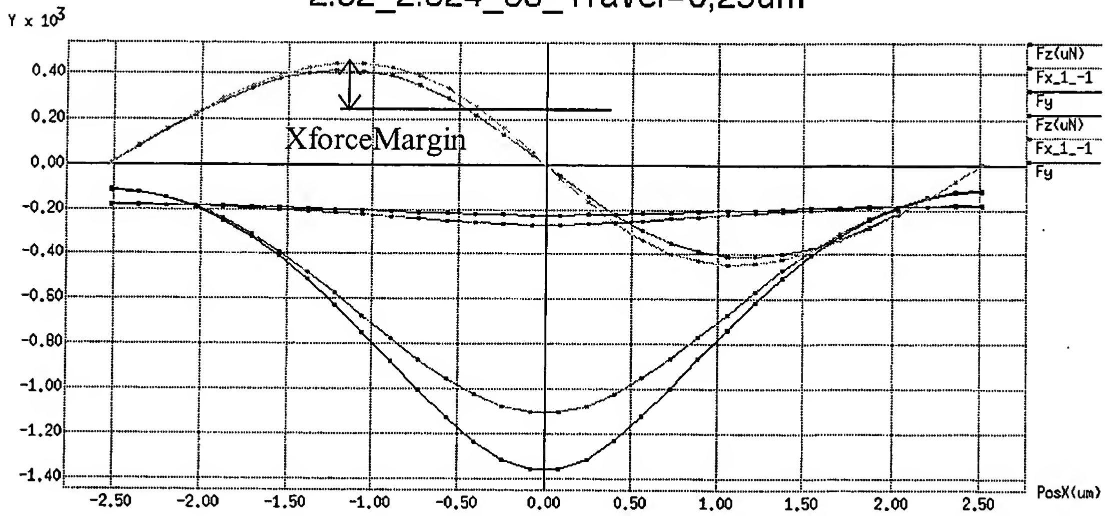
Added Velocity Feedback to model Electrostatic Damping (Based on HPL measured transfer functions vs Ve)



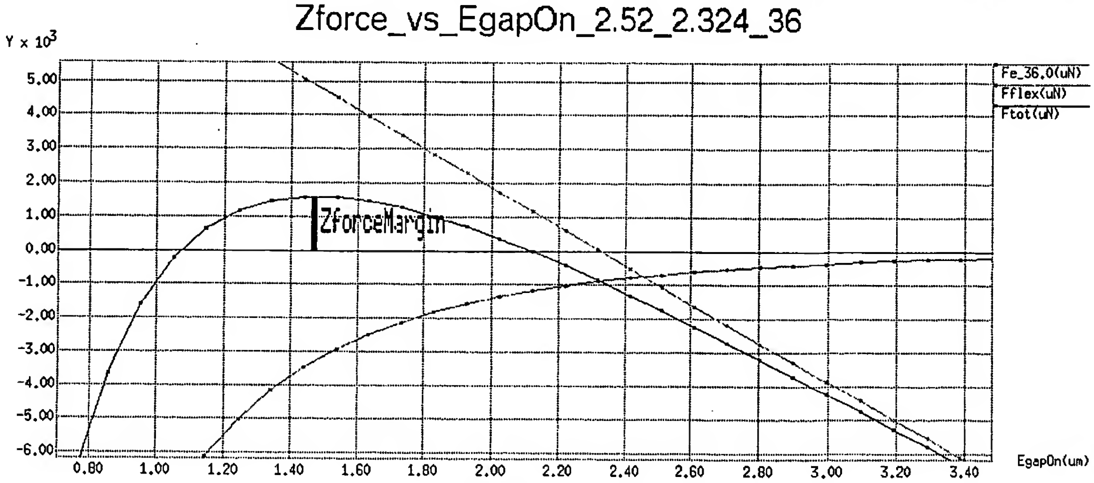
Micro-Mover



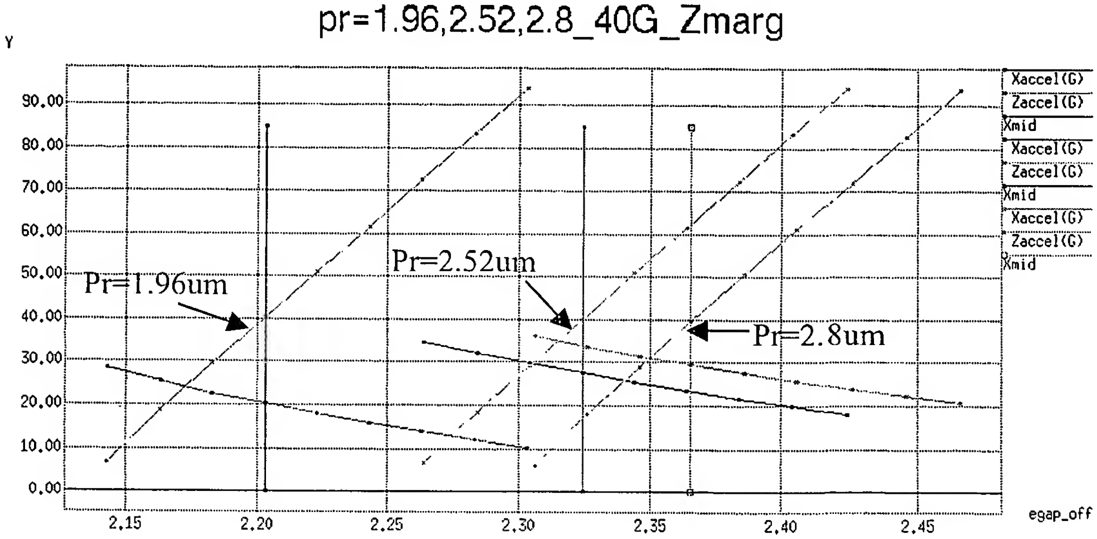
2.52_2.324_36_Travel=0,25um



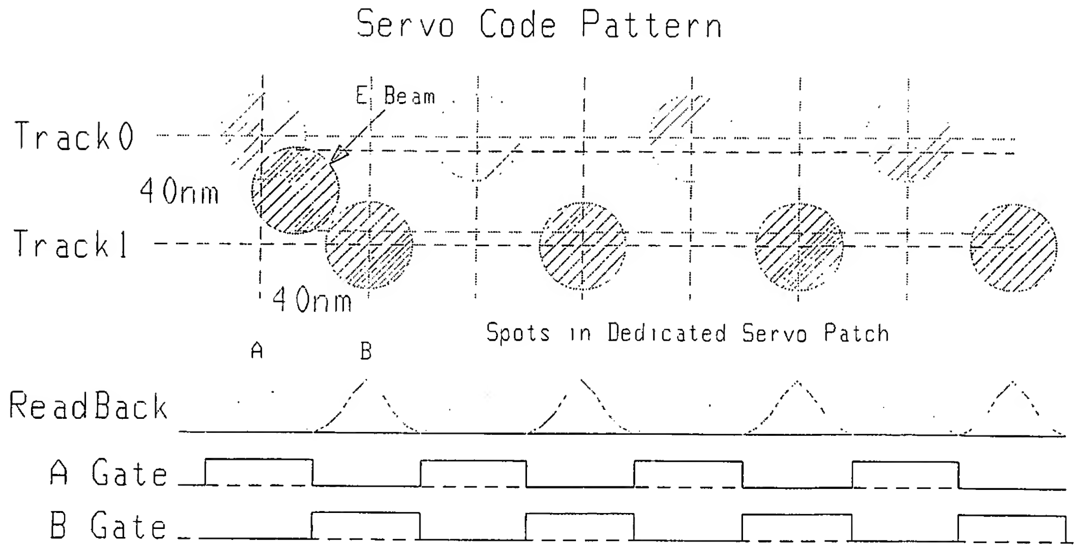
Zforce_vs_EgapOn_2.52_2.324_36



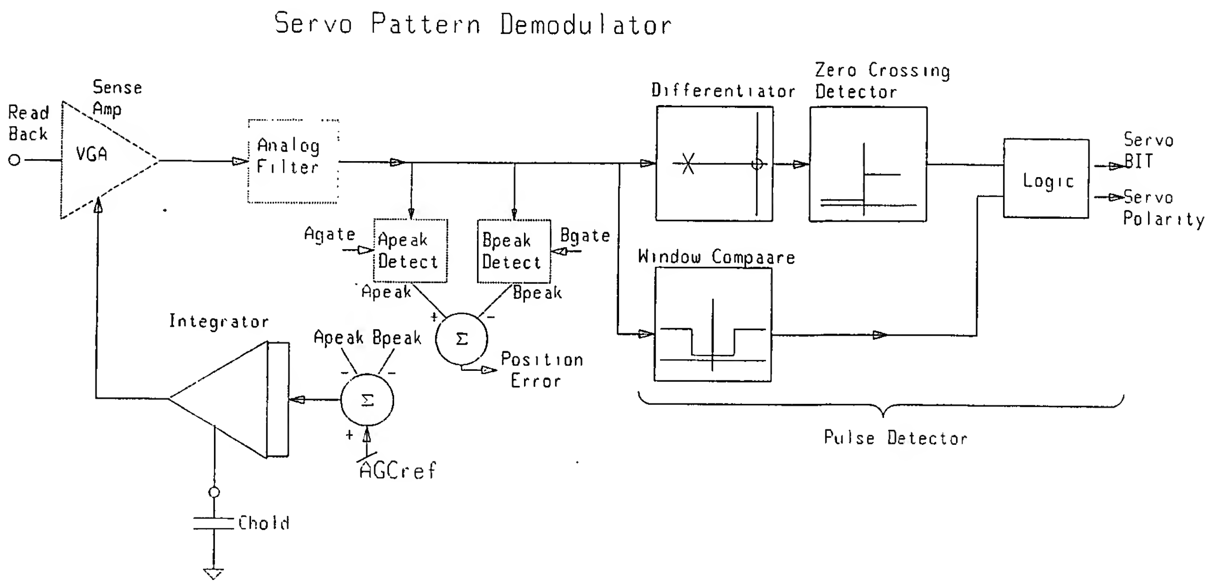
pr=1.96,2.52,2.8_40G_Zmarg



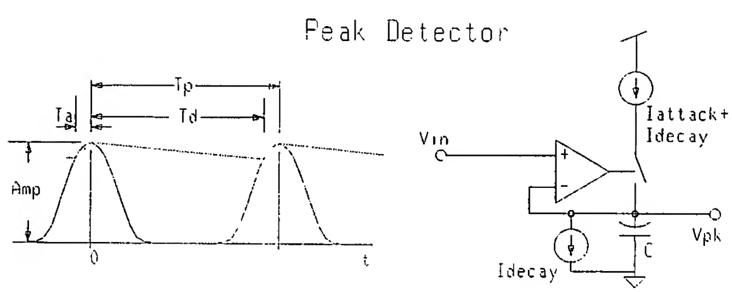
Servo Code



Servo Code Pattern
E Beam
Track0
40nm
Track1
40nm
Spots in Dedicated Servo Patch
A
B
ReadBack
A Gate
B Gate



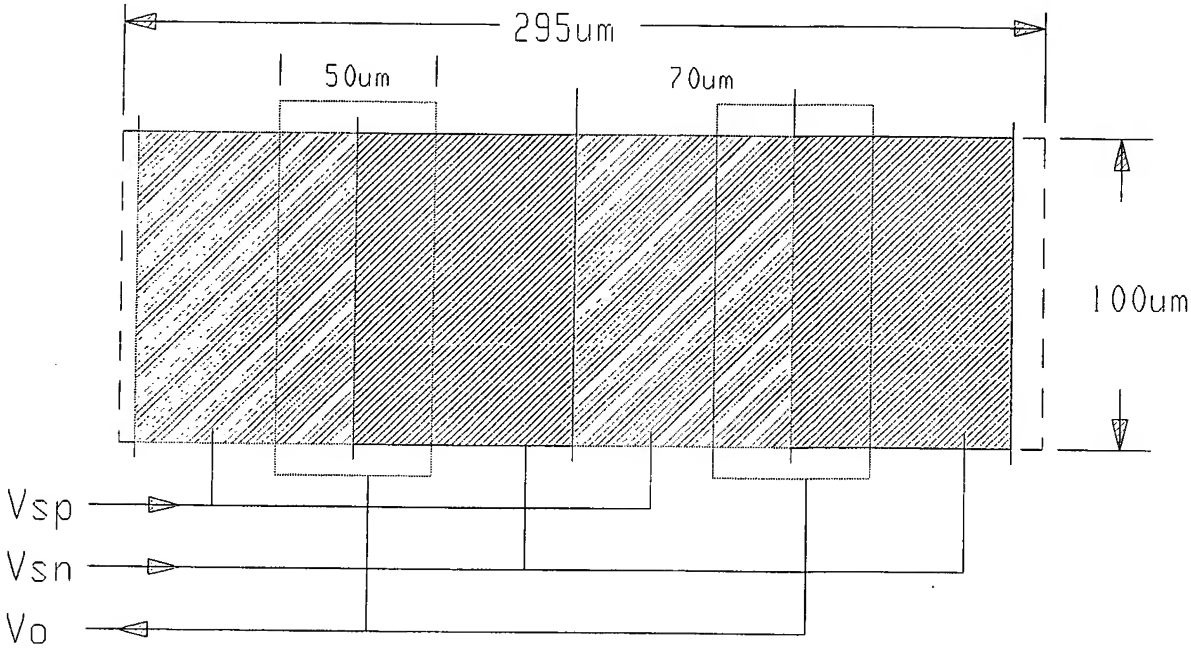
Servo Pattern Demodulator
Read Back
Sense Amp
VGA
Analog Filter
Differentiator
Zero Crossing Detector
Logic
Servo BIT
Servo Polarity
Agate
Apeak Detect
Bpeak Detect
Bgate
Apeak
Bpeak
Window Compaare
Integrator
Apeak Bpeak
Position Error
AGCref
Chold
Pulse Detector



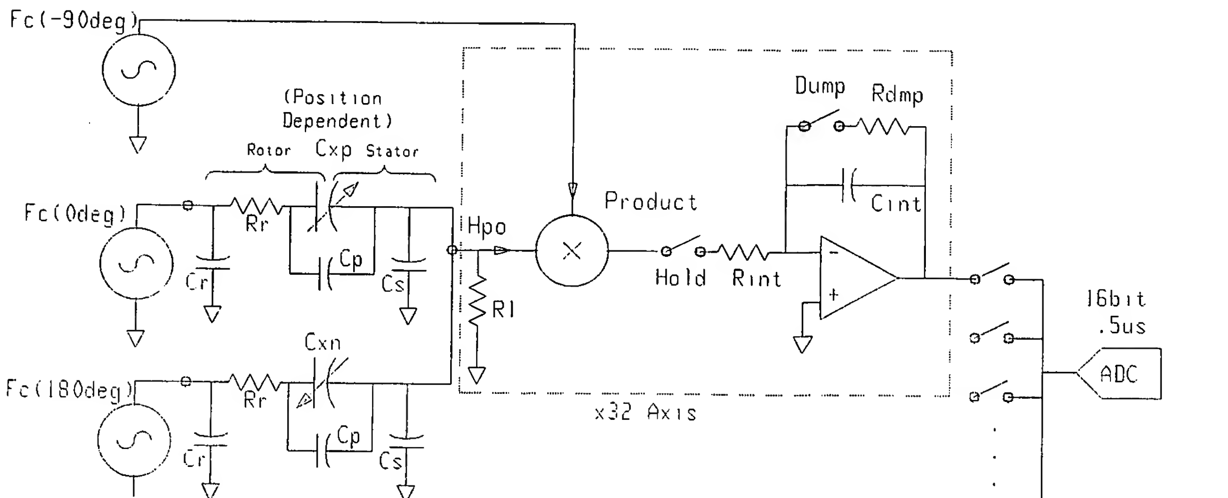
Peak Detector
Tp
Ta
Td
Amp
0
t
Vin
Iattack+ Idecay
Idecay
C
Vpk

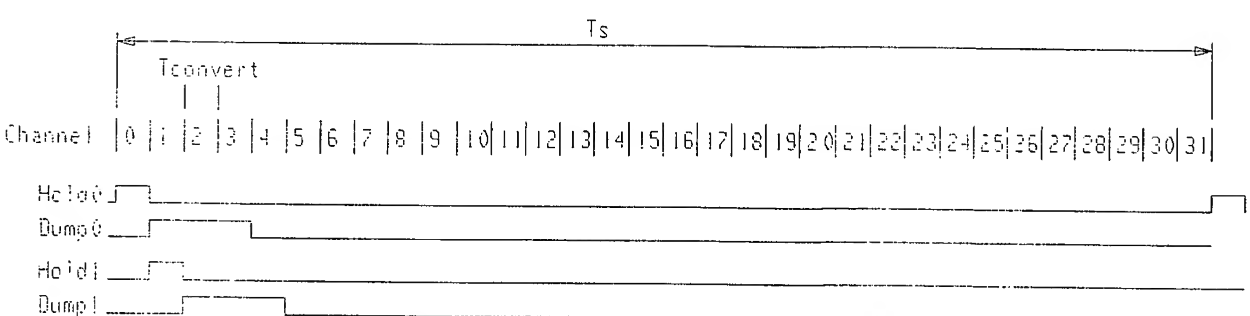
Capacitive Position Sensing

DesignB: Linear Ratiometric



Capacitance Demodulator

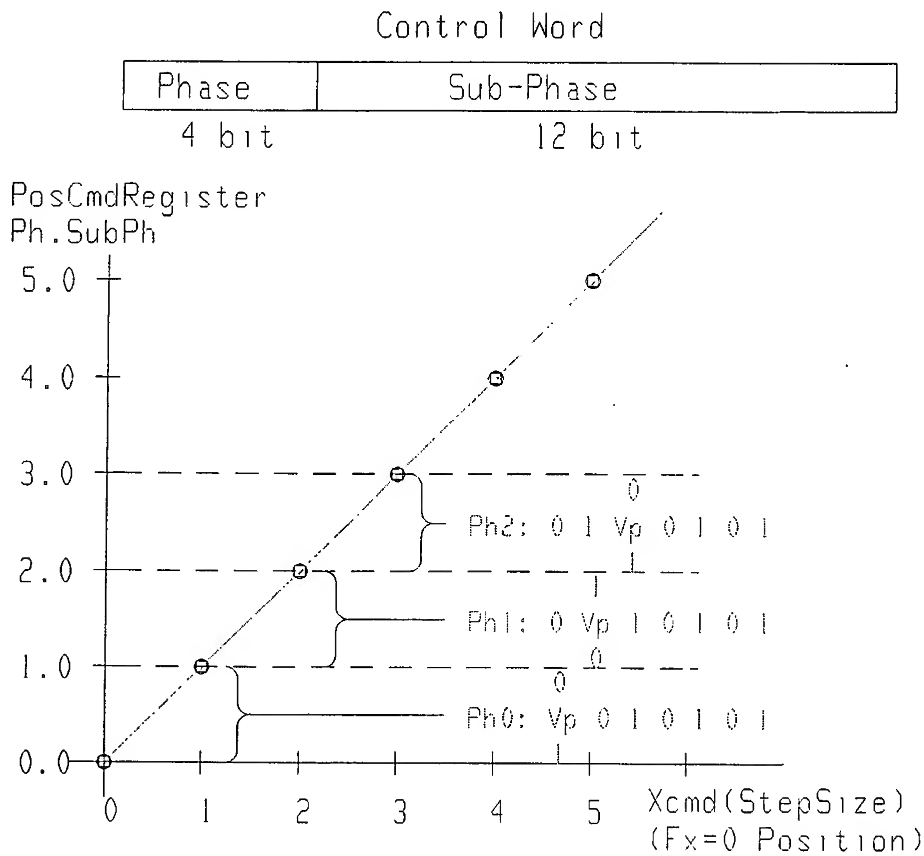


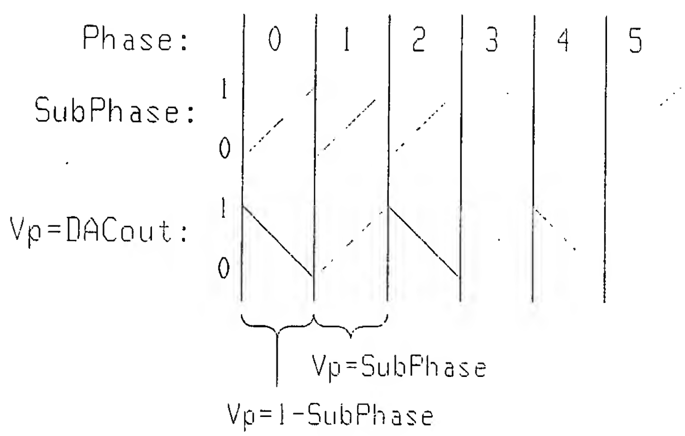


Ts=32*Tconvert
Tint=Ts-Tconvert-Tdump

Electr'ie Driver

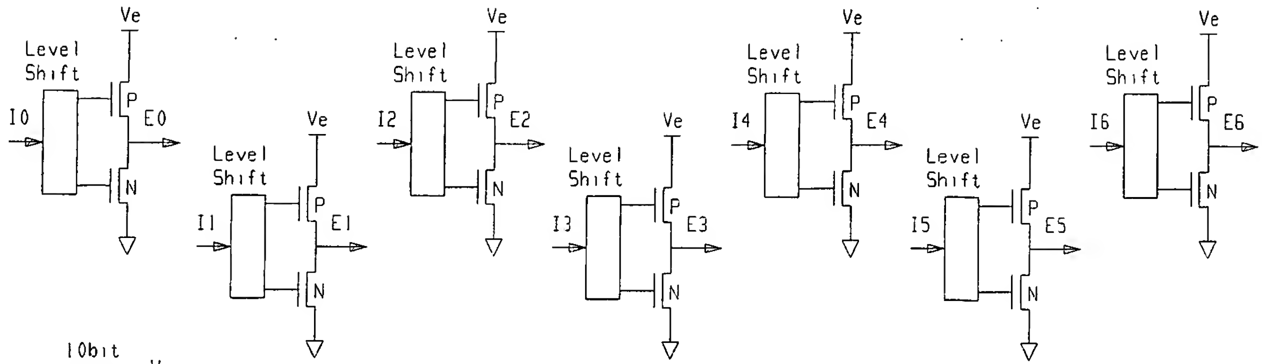
Continuous Control of MEMS Stepper Motor

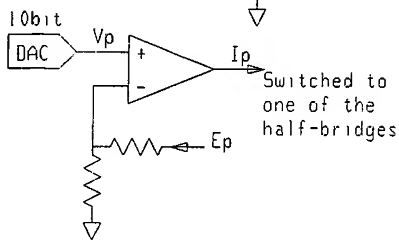




Note seamless operation across Phase boundaries and that no step changes in the electrode voltages are required.

Propo)onal Electrode Switching





Half-bridges for 7 Electrodes

Ns=7,Nr=6 Design
Rot:1 0 1 0 1 0|1 0 1 0 1 0|
Stator:
Phase\ Electrode state:

	Phase	0	1	2	3	4	5	6	
VpElectrode= Phase	0	1	0	1	0	1	0	1	1=Ve 0=Gnd on Ek
	1	0	0	1	0	1	0	1	
	2	0	1	1	0	1	0	1	
	3	0	1	0	0	1	0	1	
	4	0	1	0	1	1	0	1	
	5	0	1	0	1	0	0	1	
	6	0	1	0	1	0	1	1	← Vp Electrode (Ep,Gp)
VpElectrode= Phase-7	7	0	1	0	1	0	1	0	
	8	1	1	0	1	0	1	0	
	9	1	0	0	1	0	1	0	
	10	1	0	1	1	0	1	0	
	11	1	0	1	0	0	1	0	
	12	1	0	1	0	1	1	0	
	13	1	0	1	0	1	0	0	
	0	1	0	1	0	1	0	1	

Discovery Phase Exit Issues

1) Mover
- Insufficient Snap-down and Skip Margin
  2.52um Rotor Electrode Pitch + Higher Aspect Ratio Flexures
- High Sensitivity to process variations (Electrode Gap, Flexure Width, Electrode Voltage)
  Ve Adjustment in Manufacturing
- Mover Resonance Peak in Vacuum
  Vacuum Coffin being built to allow measurement

2) Servo Pattern Position Sensing
- Servo Pattern writing in manufacturing 30min duration
  Develop low cost per hour manufacturing test
- Pattern Demodulator Circuits x16 (Resolution, Linearity, Space, Power)
  Engage Centurion Designers to begin design

3) Capacitive Position Sensing
- Capacitive Demodulator Circuits x32 (Resolution, Linearity, Space, Power)
  Engage Centurion Designers to begin design

Web page with Orca Servo info:
don2.boi.hp.com/orca

Write in Dark Ink on Front Side Only, Please

INVENTION DISCLOSURE

PAGE ONE OF ____

PDNO 10016512 DATE RCVD 5.11.01 ATTORNEY AJB

Instructions: The information contained in this document is ***COMPANY CONFIDENTIAL*** *and may not be disclosed to others without prior authorization. Submit this disclosure to the HP Legal Department as soon as possible. No patent protection is possible until a patent application is authorized, prepared, and submitted to the Government.*

Descriptive Title of Invention: Pattern Servo Code in MEMs Device

Name of Project: Orca

Product Name or Number:

Was a description of the invention published, or are you planning to publish? If so, the date(s) and publication(s):

No

Was a product including the invention announced, offered for sale, sold, or is such activity proposed? If so, the date(s) and location(s):

No

Was the invention disclosed to anyone outside of HP, or will such disclosure occur? If so, the date(s) and name(s):

If any of the above situations will occur within 3 months, call your IP attorney or the Legal Department now at 1-898-4919 or 970-898-4919.

Was the invention described in a lab book or other record? If so, please identify (lab book #, etc.)

Was the invention built or tested? If so, the date:

No

Was this invention made under a government contract? If so, the agency and contract number:

No

Description of Invention: *Please preserve all records of the invention and attach additional pages for the following. Each additional page should be signed and dated by the inventor(s) and witness(es).*

A. Description of the construction and operation of the invention (include appropriate schematic, block, & timing diagrams; drawings; samples; graphs; flowcharts; computer listings; test results; etc.)
B. Advantages of the invention over what has been done before.
C. Problems solved by the invention.
D. Prior solutions and their disadvantages (if available, attach copies of product literature, technical articles, patents, etc.).

Signature of Inventor(s): Pursuant to my (our) employment agreement, I (we) submit this disclosure on this date: [ ].

Employee No.	Name	Signature	Telnet	Mailstop	Entity & Lab Name
	Donald J Fasen	Donald J. Fasen			PSB

(If more than four inventors, include additional information on another copy of this form and attach to this document)

Write in Dark Ink on Front Side Only, Please

INVENTION DISCLOSURE COMPANY CONFIDENTIAL PAGE ____ OF ____

Signature of Witness(es): *(Please try to obtain the signature of the person(s) to whom invention was first disclosed.)*

The invention was first explained to, and understood by, me (us) on this date: [ ]

Full Name	Signature	Date of Signature
Richard L Hilton	Richard L Hilton	5/10/01
Full Name	Signature	Date of Signature

Inventor & Home Address Information: *(If more than four inventors, include addl. information on a copy of this form & attach to this document)*

Inventor's Full Name
Donald J. Fasen

Street

City State Zip

Do you have a Residential P.O. Address? P.O. BOX City State Zip

Greeted as *(nickname, middle name, etc.)* Citizenship

Inventor's Full Name

Street

City State Zip

Do you have a Residential P.O. Address? P.O. BOX City State Zip

Greeted as *(nickname, middle name, etc.)* Citizenship

Inventor's Full Name

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Inventor's Full Name

Street

City State Zip

Do you have a Residential P.O. Address? P.O. BOX City State Zip

Greeted as *(nickname, middle name, etc.)* Citizenship

Pattern Servo Code in MEMs Device

Updated: Thursday, 10-May-2001 12:24:01 MDT

5/9/01

Abstract

A high resolution position signal and timing generator is created using a patch of pre-written spots on the Orca media. The position signal is used to control the resonances in the mover and maintain the accurate and repeatable across track positioning needed for data integrity. The timing is needed for proper placement of the data bits down the track during writing of the data and for proper timing of the bit windows during data reads.

Background

In order to implement servo control for the Orca mover, a position sensor capable of indicating the relative position of the rotor with respect to the emitter wafer is required. To achieve the high data capacity of the Orca module, the center to center track spacing is only 40nm. This small track pitch requires precise positioning of the tracks relative to the emitters which access the data on these tracks.

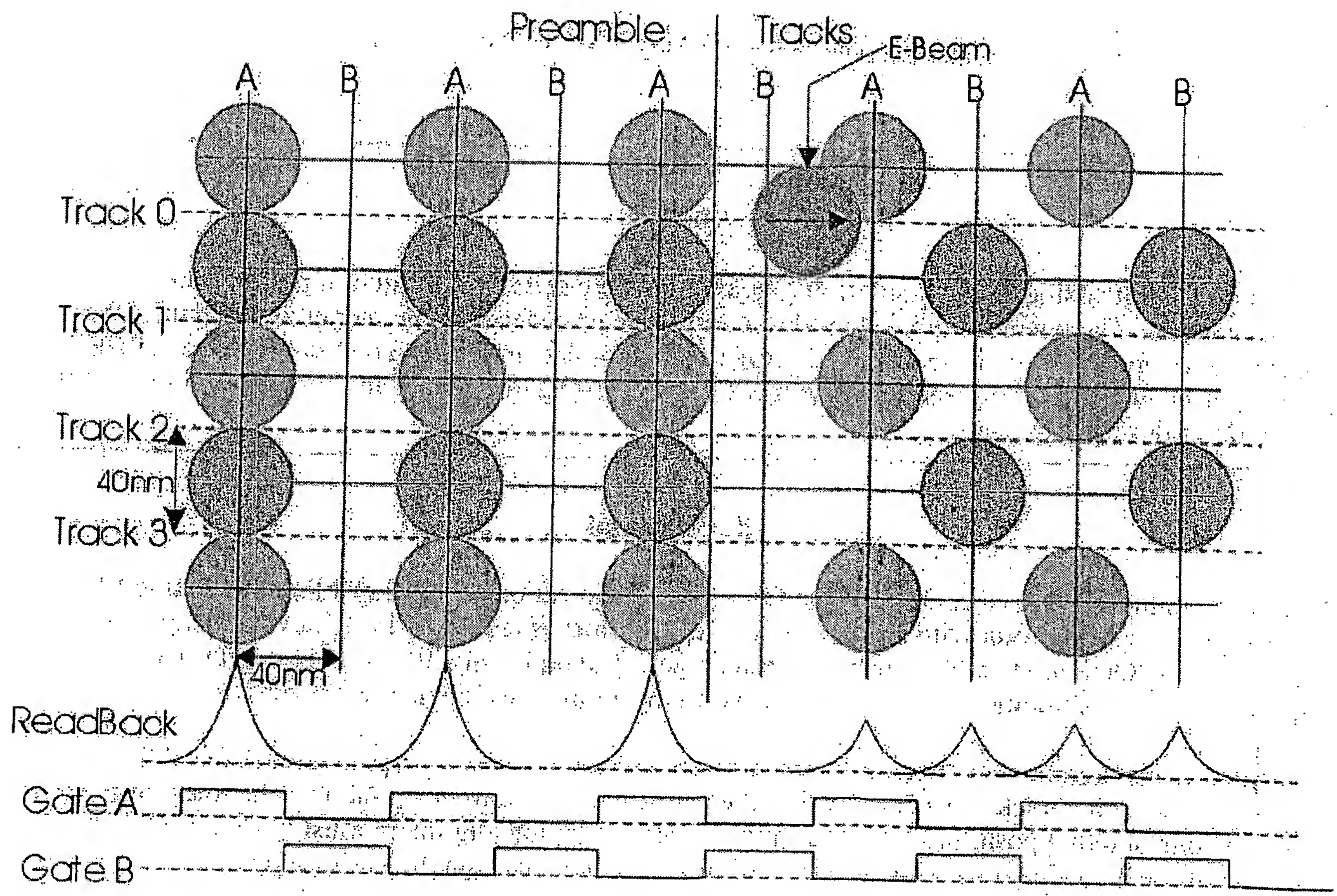
Typically, a misalignment of 10% of the track pitch will cause a severe degradation in the ability to recover the data on a track. This implies that the positioning system must maintain the track alignment to less than 4nm and that position sensors used to maintain position alignment must have a resolution of less than .4nm. This fine resolution is very difficult to achieve in a small, low cost device.

Reliable data recovery also requires accurate down the track timing information to properly window the data bits. This timing must be available before any data is written on the tracks so that the data can be written with uniformly spaced bits down the track.

Servo Pattern

The servo pattern approach presented can achieve these position resolution and timing generation requirements.

Servo Code Pattern



The pattern is written using the same type of media and emitters used to write data bits.

Since the across track pitch of the servo bits is the same as the track pitch, the full scale range of the position signal generated from the servo bits is one track. This allows for an across track resolution which scales with the track pitch and allows for a position signal with resolution which is a small subdivision of the track.

Similarly, the servo bits are pulse detected down the track to create a digital pulse stream which can be fed to a Phase Locked Loop for smoothing and defect tolerance. The clock generated by this PLL can be used for timing of the data write pulses and for framing data readback pulses.

The writing and reading of the servo pattern uses the same methods as are used in writing and reading the data bits. This allows for the same emitters and sense diodes to be used for servo pattern channel. Also, most of the signal processing electronics are identical to the read/write electronics allowing for minimal additional circuit design.

There is a pair of servo tracks for each of the 1000 data tracks in a data patch and the servo read beam will be centered between 2 adjacent servo tracks when the data beams are centered over the data tracks. The servo pattern is written in 4 patches on the media during the manufacturing process. This allows for

Pattern Servo Code in MEMs Device

Updated: Thursday, 10-May-2001 12:24:01 MDT

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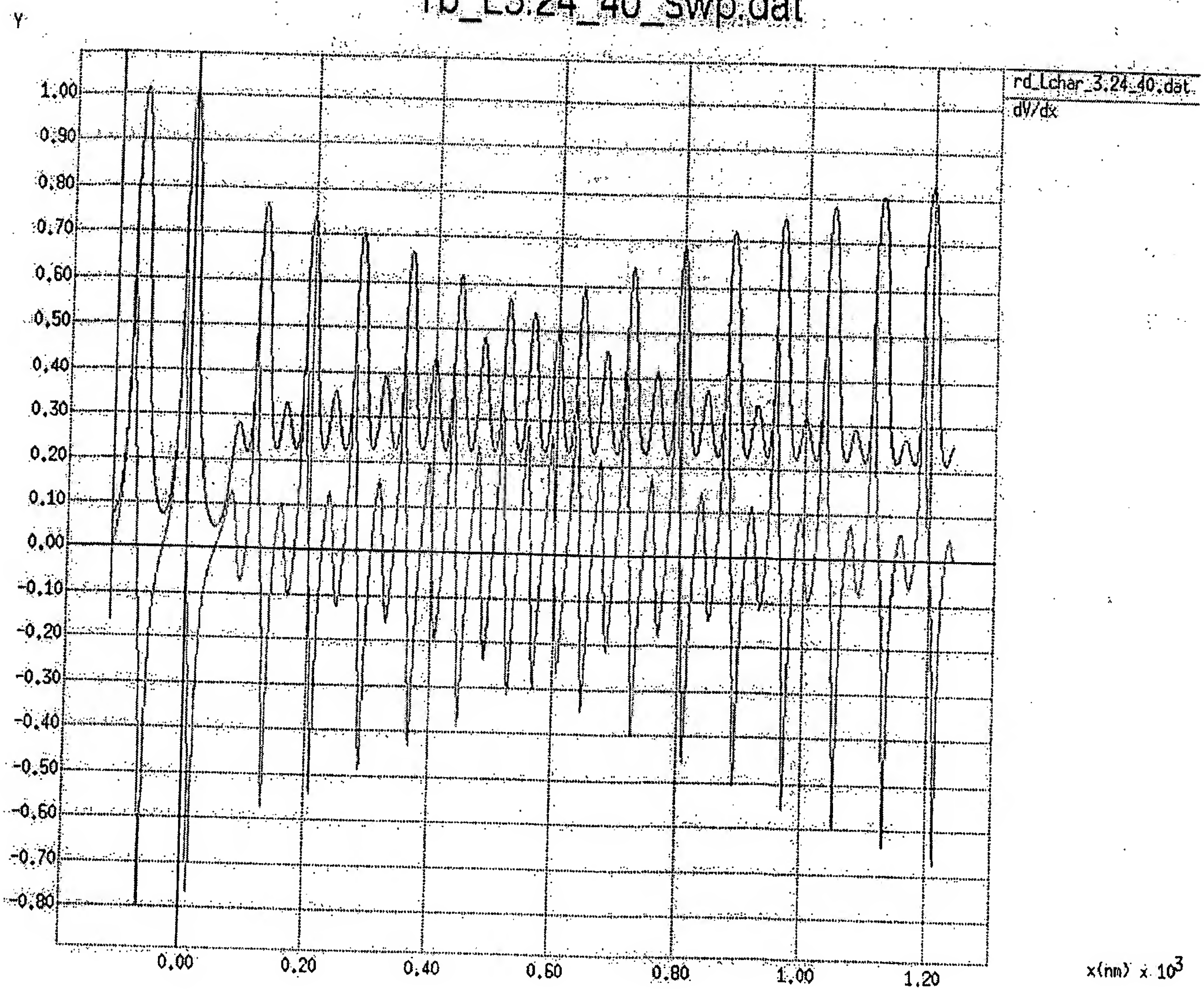
rb_L3.24_40_swp.dat



any 3 of the 4 servo emitters to be defective and still read the servo pattern. Grouping the servo patches in a center cluster allows the used of a single sense diode for the servo signal readback. This allows reduces the media overhead for the servo patches and allows the signals from any of the servo patches to be routed off of the mover with a single pair of traces.

Since the servo patches are never written in normal use, the write capability can be disabled at the end of the manufacturing process to ensure that the servo pattern is not overwritten.

Many other servo patterns are possible including patterns with track identification marks, special timing marks and burst A-B pulse patterns. The pattern shown here is being considered because of it's simplicity.

Model of readback of servo pattern

Below is a plot of a -4nm to +4nm sweep across the servo pattern tracks. The red trace is the raw readback signal while the green trace is the differentiated signal. Either or both of these signals may be used for position and timing generation.

The preamble ends after the pulse at x=0.

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The preamble ends after the pulse at x=0.

ELLIS,HEATHER (Non-HP-Boise,ex1)

From: LEGAL,IP (HP-PaloAlto,exgen1)
Sent: Wednesday, July 25, 2001 1:31 PM
To: FASEN,DON (HP-Boise,unixgw1)
Subject: Invention Disclosure 10016512

*** Please do NOT reply to this message as the "From" mailbox is NOT monitored. ***

Thank you once again for submitting your invention disclosure entitled "Pattern Servo Code In MEMs Device" to the Legal Department's Intellectual Property section. Patents are very important to HP and we could not protect HP's many fine inventions without inventors like you who take the time to prepare invention disclosures.

The decision has been made to pursue patent protection and prepare a patent application for your invention for filing in the US Patent and Trademark Office and potentially other patent offices around the world. The purpose of this correspondence is to inform you that we have arranged for Steven E Dicke of the law firm Dicke Billig & Czaja PA to work with you to prepare the patent application. The attorney will be calling you shortly to set up a time to discuss your invention and the application. Please feel free to work with this non-HP attorney and be sure to mention any publication or disclosure related to your invention which has already occurred or which may occur before the application is filed. You may call Steven E Dicke at 612 573 2000

Again, thank you very much for your efforts. If you should have any questions, please give me a call at Telnet 396-3597.

Sincerely,

Anthony J Baca
Legal Department
Intellectual Property Section

Hewlett-Packard Company
11307 Chinden Boulevard
Mail Stop 314
Boise, ID 83714
www.hp.com

invent

Steven R. Ormiston
PATENT ATTORNEY/OUTSOURCING MGR

208 396 2544 Tel
208 396 3958 Fax

July 25, 2001

Steven E. Dicke
Dicke Billig & Czaja PA
Suite 1250 701 Building
701 Fourth Ave South
Minneapolis MN 55415

RE: Preparation ***and filing*** of Patent Applications for the attached Invention Disclosure(s)
10015022-1, 10051371-1, 10016512-1, 10016684-1, 10016685-1, 10017377-1, 10017387-1, 10017388-1(combine w/ 10017389), and 10017394-1

Pursuant to Outside Counsel Procedures Dated October 15, 1999

FILE DIRECTLY TO THE USPTO by: December 27, 2001

Dear Steve:

We would like you to provide us with a quote of the cost for your firm to prepare ***and file*** (direct with the USPTO) a US patent application based on the HP invention disclosure(s) identified above, a copy of which is enclosed. Your quote should be based on preparing and filing this application **exactly as specified on the attached green checklist**.

You must use HP's USPTO forms and only reference HP's "complete" docket number on all filing documents and correspondences with the USPTO. All filing fees should be charged to HP's deposit account noted on the HP forms. Please do not prepare or file an assignment, HP will do that. Any questions regarding HP's forms and the JetForm software for use with HP's forms should be directed to Jennifer Torres at (858) 655-8008.

Your quote should be submitted on the enclosed Request for Quote And Engagement Letter Agreement. If your quote is accepted, we will return a fully executed copy of the Agreement to you for your records. **The Agreement will not be binding on you or on HP until signed by HP's authorized representative. If the Agreement is not signed and returned to HP, any bills submitted by you cannot be paid.**

Thank you for your assistance in this matter. If your review indicates a possible conflict for your firm, you should advise us within one week of receipt of this letter.

Sincerely,

Chris Griffin For Steven Ormiston

Steven R. Ormiston

Enc.: HP Invention Disclosure(s)
RFQ(s)
Outside Counsel Checklist(s)

Reques__r Quote and Engagement Letter __reement

RE: Hewlett-Packard Docket No.10016512-1

Application No.: Confirmation No.:

X This is a request for a quote for the following services:
__ This is a confirmation of your quote for the following services:

PREPARE

X Application | X File with USPTO
__ Response | __ Return to HP for filing
__ Other ____________________

X YOUR FINISHED PRODUCT TO HP SHOULD INCLUDE ALL ITEMS ON THE ENCLOSED CHECKLIST.

HP REQUIRED DATES: ____________ Date for Receipt by HP
Dec. 27, 2001 Date to be Filed in PTO

HP Attorneys of Record: (to be included on the Declaration)

Customer Number 022879

HP Primary Technical Contact: Donald J Fasen

Telephone No.: (208) 396-3299 **FAX No.:**
HP Entity: PSB
Address: Contact Inventor for Current Information

ADDITIONAL TERMS OR INSTRUCTIONS:

*Please list Anthony J Baca (ph. 208 396 3597) on the DEC and POA as the contact for USPTO inquiries.
*We will need foreign Claims/Abstract with reference numbers for foreign filing

TOTAL PRICE: ____________________ **(including Formal drawings)**

I agree to the terms of this Agreement including the additional terms above, pursuant to the HP Procedures for Outside Counsel revised **OCTOBER 15, 1999**, a copy of which I have received and reviewed. This Agreement will not be binding on either party until signed by an authorized representative of HP.

Dicke Billig & Czaja PA | **HEWLETT-PACKARD COMPANY**

By: ____________________ Steven E. Dicke | **By:** ____________________ Steven R. Ormiston

Dated: ____________________ | **Dated:** ____________________

Rev06/01 (ELA)

Checklist

For Preparing USPTO Application
and USPTO Office Action Response
by Outside Counsel

Customer Number 022879

HP PDNO 10016512-1

Date for Receipt by HP ____________

Your ref. No. ____________

Date to be Filed in USPTO DEC. 27, 2001

NEW APPLICATIONS

___ Request for Quote executed and returned to HP for signature (Via FAX)

___ Final draft approved by inventor(s) and HP Responsible Attorney as necessary and submitted to HP

___ Confirmation postcard addressed to HP(*Boise)

___ Copy of all filing documents for HP's file **within one week from filing**

___ Transmittal Letter

___ Prepared Declaration and Power of Attorney indicating HP as the only correspondent and send to Chris Griffin for signatures and return to O/C for filing

___ Prepared Assignment and send to Chris Griffin for signatures *& filing by HP*

___ Copy of Application on A4 paper

___ Set of claims reduced to 10 and Abstract with reference numbers for filing in Europe

___ Formal drawings according to EPO format

___ IDS (if applicable), Form 1449 and copy of references

___ Electronic copy of application on diskette (not via email or internet)

___ **Copy of transmittal faxed to HP on date application mailed to USPTO by O/C**

___ Shortest independent claim has 175 words or fewer

Chris Griffin
Hewlett-Packard Company
Legal Dept. 314
P.O. Box 15
Boise, ID 83707

OFFICE ACTION RESPONSE

___ Request for Quote executed and returned to HP for signature

___ Final draft approved by inventor(s) and Responsible Attorney as necessary and submitted to HP

___ Confirmation postcard addressed to HP (*Boise)

___ Copy of all filing documents for HP's file **within one week from filing**

___ Transmittal Letter

___ Amendment or other response (continuation, etc.) on A4 paper

___ Electronic copy of response on diskette (not via email or internet)

___ IDS (if applicable), Form 1449 and copy of references

___ **Copy of transmittal faxed to HP on date amendment/response mailed to USPTO by O/C**

___ Petition for Extension of Time if required

___ Shortest independent claim has 175 words or fewer

Revision Date
12/7/2000

Steven R. Ormiston
Patent Attorney-Outsourcing Manager
IP Section, Legal Department
208 396 2544 Tel
208 396 3958 Fax
steve_ormiston@non.hp.com

July 24, 2002

Steven E. Dicke
Dicke Billig & Czaja PA
701 Fourth Ave South
Suite 1250
Minneapolis, MN 55415

Re: New Patent Applications Transfer of Responsibility

Dear Steven:

Please be informed that the following Hewlett-Packard cases have been transferred from the Boise, Idaho Intellectual Property Department. to Gus Winfield in our Fort Collins, Colorado Intellectual Property Department.

10007398-1	10010697-1	10010705-1	10010706-1
10010711-1	10010716-1	10010726-1	10010727-1
10010728-1	10010742-1	10011206-1	10012692-1
10013804-1	10013891-1	10013896-1	10013899-1
10014042-1	10014151-1	10014155-1	10014168-1
10014200-1	10014219-1	10014224-1	10014228-1
10014230-1	10014232-1	10014239-1	10014243-1
10014244-1	10014246-1	10014258-1	10014266-1
10014268-1	10014272-1	10014275-1	10014281-1
10014282-1	10014286-1	10014296-1	10014298-1
10015022-1	10016512-1	10016684-1	10017377-1
10017387-1	10017388-1	10017394-1	10017421-1
10017494-1	10017499-1	100110802-1	100110973-1
100202553-1	100202730-1	100204485-1	100204496-1
200205279-1	200205281-1	200205282-1	200205286-1
200205504-1	200205508-1	200205516-1	

All future correspondence should be sent to the attention of Mr. Winfield at the address shown below.

Augustus W. Winfield
Senior Managing Counsel
Hewlett-Packard Company
3404 E. Harmony Rd., MS 79
Ft. Collins, CO 80528-9599
(970) 898-3142 Tel
(970) 898-7247 Fax
gus_winfield@hp.com

Thank you for your assistance in these matters.

Sincerely,

HEWLETT-PACKARD COMPANY

Steven R. Ormiston

SRO/hae

Servo System Review 11/02

- Deliverables and Dependencies
- Servo Block Diagram
- Status
  - -Motor
  - -Motor Driver
  - -Capacitance Sensor
  - -Servo Pattern
  - -Digital Controller
- Shock and Vibration
- Manufacturing

Deliverables

- 2ms profiled track scan
- 30mm/s scan velocity for 750K BitCell/sec/channel data rate
- <15% track (4nm-6nm) across track repeatability for error-rate goals
- Multi-phase, BitCell rate (1x) tracking clock and Start_of_Track timing with short term errors <10% bit and long term errors <1 bit

Dependencies

- Process
  - Deep Etch of mover and flexures
  - Egap
- Mechanics
  - Layout
  - Motor and Cap Sensor Electrodes
- Channel (Emitters, Media, R/W)
  - Servo pattern write and read-back
  - Low noise to allow .02nm resolution PES
  - Off-track Capability of >10%
  - Linear across-track profile
- Firmware
  - Move and scan control
  - Diagnostics, calibration, tuning, data reporting
- Power Supply
  - Adjustable Ve 25-60v

Risks

- Not meeting schedule and/or deliverable requirements

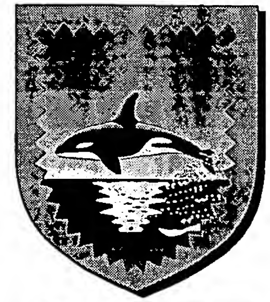
- Schedule risks are high due to
  - Long lead-time of the components (motors, sensors, electronics)
  - Unknown characteristics of these components

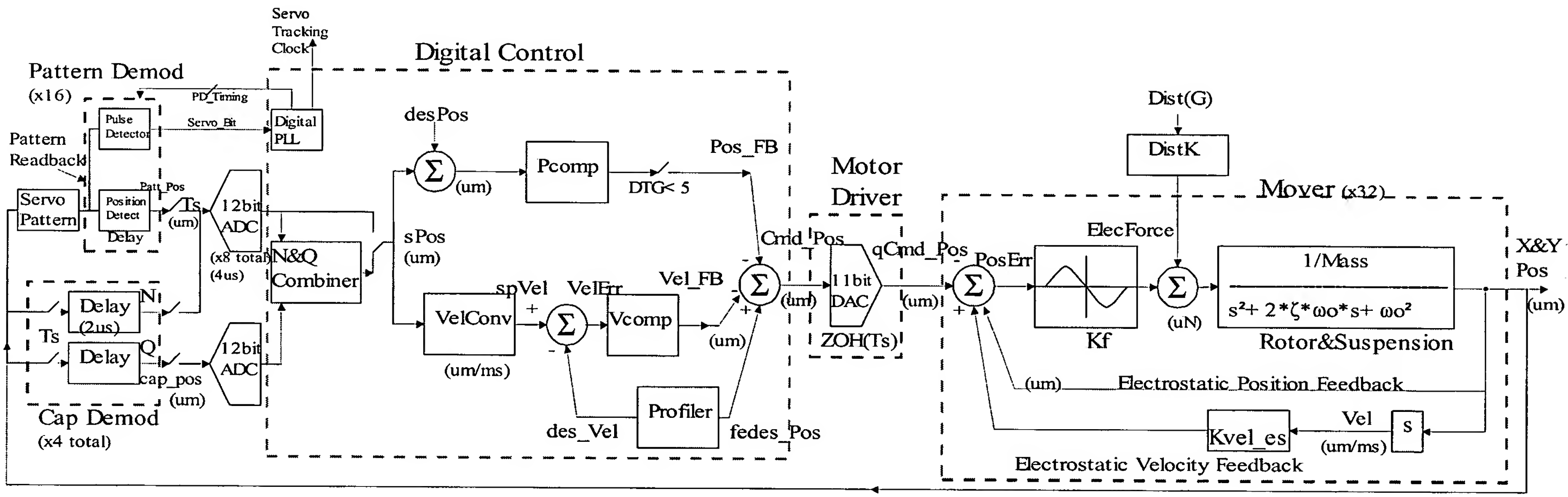
- Mitigation includes:
  - Starting the development early
  - Modeling
  - Finding ways to shorten the lead-time
  - Relaxing the requirements

Servo Block Diagram

- •Mover (x16)
- •Motor Driver (x32)
- •Digital Controller (Time shared DSP)
- •Capacitance Demodulator (x4)
- •12bit ADC (x8)
- •Pattern Demodulator (x16)

Return to Previous Slide





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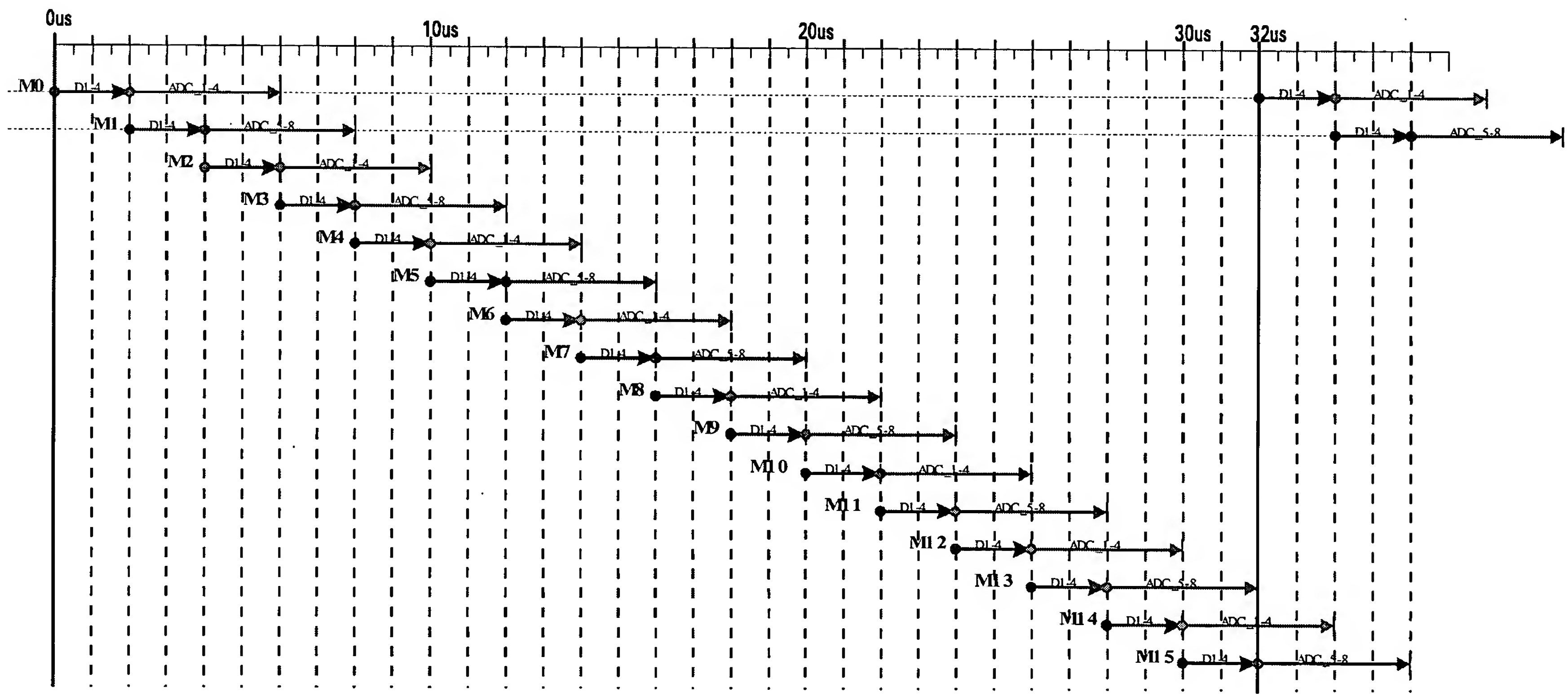
System Timing

Concepts

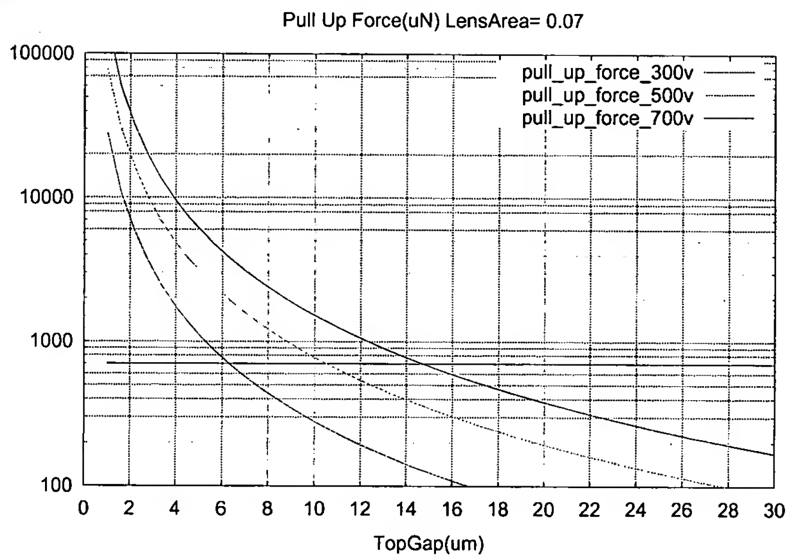
- Time-shared analog and digital hardware to reduce power consumption
- Master timing generator to synchronize CapDemod, ADC, PatternDemod and digital control blocks and allow power management.



Motor Design

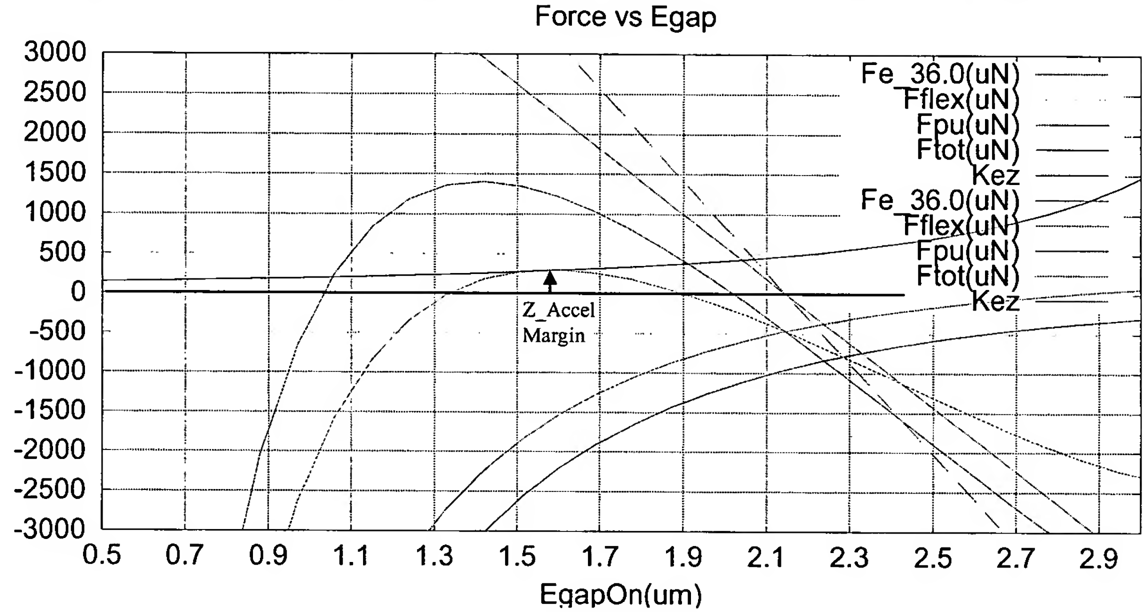
- Pull-up vs Snap-down
- Peak In-Plane Force Optimization (X_Accel & Z_Accel Margin)
- Measured Results
- Motor Driver

Block Diagram

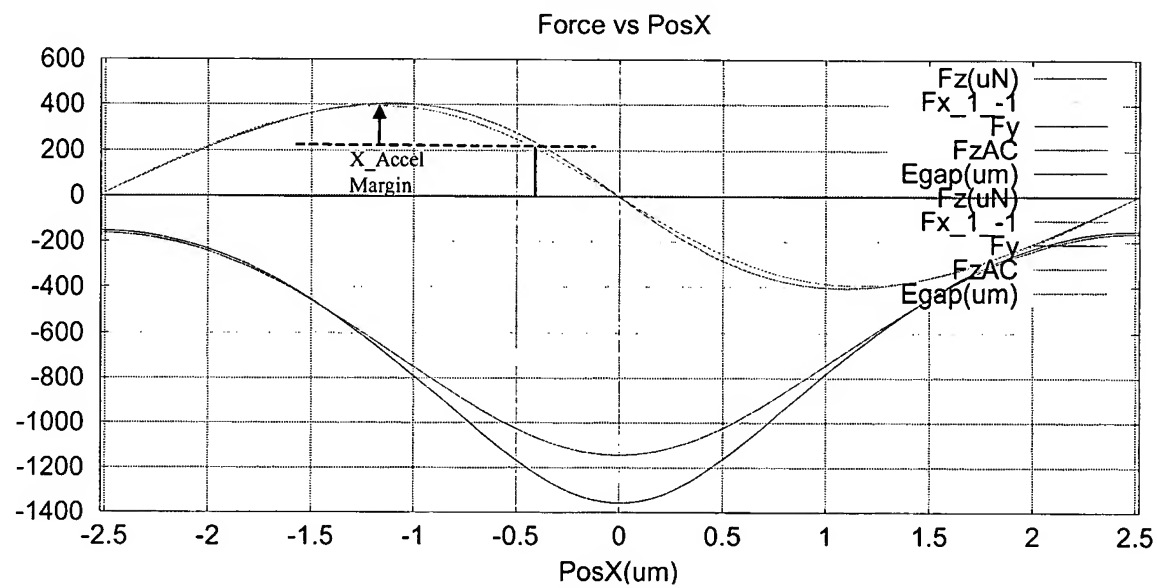


Pull-up Force from Lens and
Flat Emitters
Without Shield:
Vpu=700v
AreaPu=.07mm^2 (lens area)
TopGap=7um
Gives
Fpu=3118uN >> 700uN limit

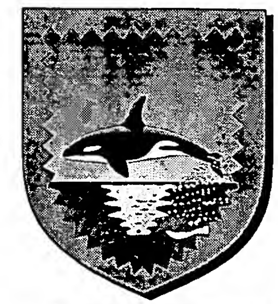
Motor Performance vs Stroke



Z_Accel Margin indicates margin against snap-down



X_Accel Margin indicates margin against skittering



For both plots:

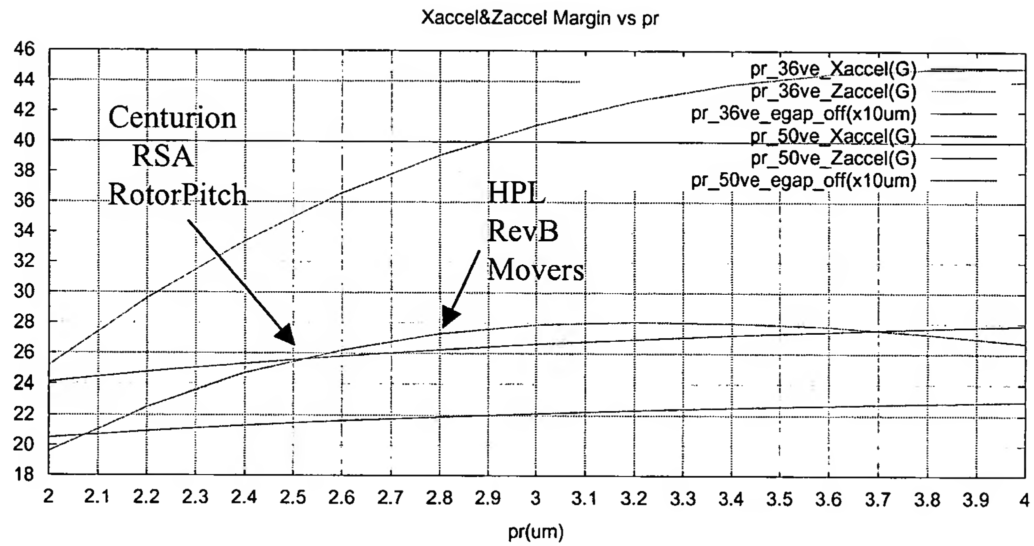
Set1=0 position
Set2=25um

PuV=13.1v
PuGap=2um

Current Design:
(shown here)
Z_Accel=40G
X_Accel=20G

invent

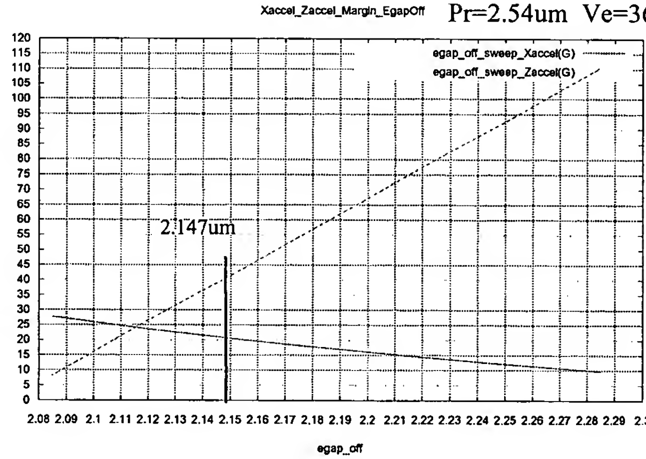
Motor Optimization



Pr=N*.04*7

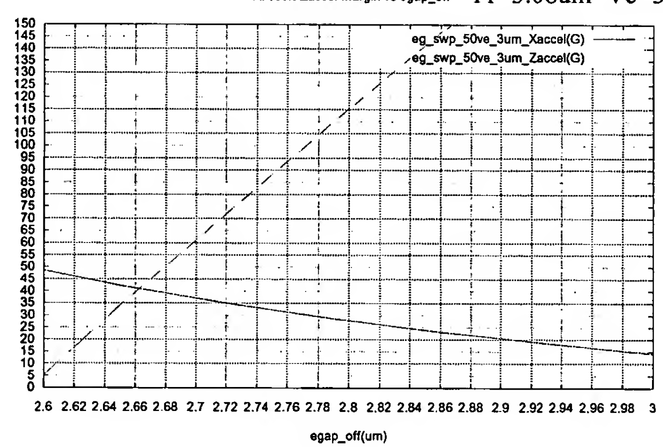
N	pr	StepSize	MD_lsb
10	-> 2.8	.4um	.19nm
11	-> 3.08	.44um	
12	-> 3.36	.48um	.23nm
13	-> 3.64	.52um	.25nm

Pr=2.54um Ve=36v Design



Sensitivity:
-89 Gx/um
511 Gz/um

Pr=3.08um Ve=50v Design

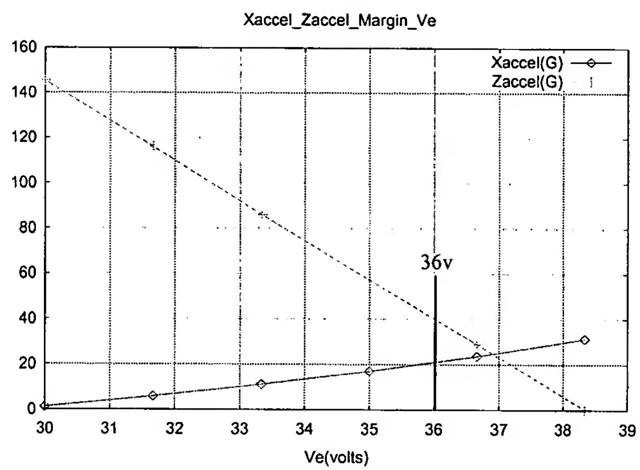


Sensitivity:
-86Gx/um
500Gz/um

+/-.1um Egap variation will change the Z_Accel margin +/-51G!

Ve Tuning

Pr=2.54um Ve=36v Design

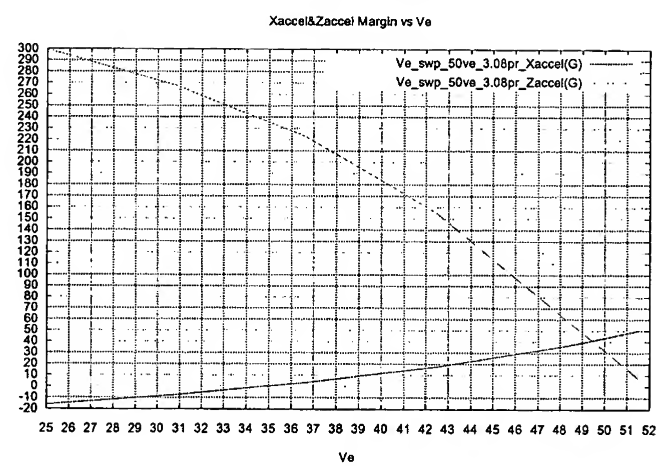


Sensitivity:
3.6 Gx/volt
-17.4 Gz/volt

- Adjust Ve to account for variations in EgapOff (3v/.1um_egap)

Egap	500	Gz/um							
	-86	Gx/um							
	2.692	um							
Ve:	-16.4	Gz/v							
	3.52	Gx/v							
	50	v							
EgapDelta	0.3	um							
			Zmarg		Xmarg		DeltaVe	Ve	Xmarg
+Delta	2.992	um	150	Gz	-25.8	Gx	9.146341	59.14634	6.395122
-Delta	2.392	um	-150	Gz	25.8	Gx	-9.14634	40.85366	-6.39512
Effect of Ve tuning on modeled performance:									
	Ve						FoOn	FxPeak	
NomEgap	50		50	Gz	40	Gx	4453.5	513.3	
+Delta	59.14		74.9	Gz	41.1	Gx	4502.2	525.3	
-Delta	40.85		41.7	Gz	33.1	Gx	4226.3	465.9	

Pr=3.08um Ve=50v Design

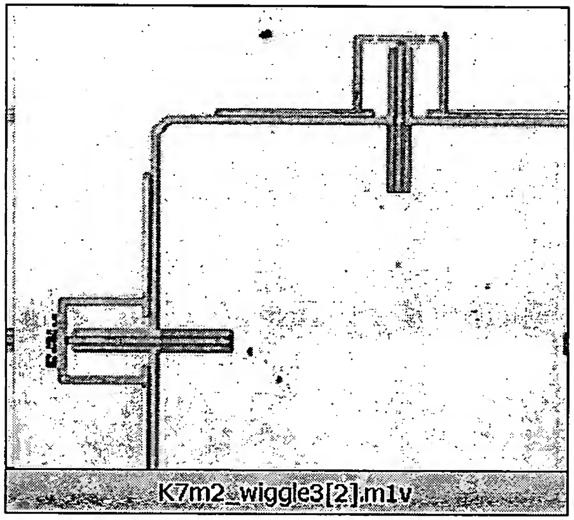


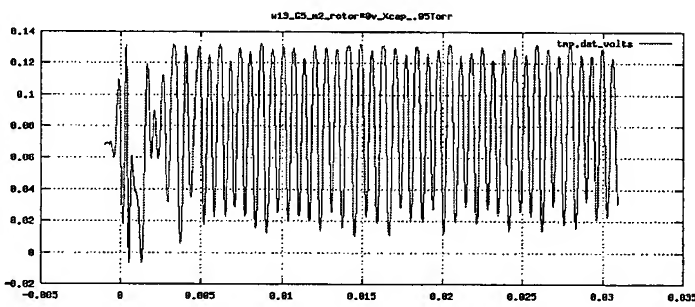
>40v:
3.52Gx/volt
-16.4Gz/volt

Overall:
2.52Gx/volt
-11.4Gz/volt

Measured Results

Centurion RSA





Centurion RSA Mover Results

Method:
From:
  Rotor Thickness -> Mass (0.750uKg)
  FringXY_off -> KflexureXY
  FringZ_off -> KflexureZ
  FringXY_on -> Egap_off (using solver in model)
 then compare model vs measured for:
  FringZ_on (Hz)
  Zpull_down (nm)
  Steps to Skitter (peak force uN)
as a function of electrode voltage.
The effective beam widths are then calculated from KflexureX

Given the freedom to adjust Egap_off based on the measure FringXY_on, the model matches the measured within a few percent

W12_G7m2 Results:
Fring_off=550Hz KflexureXY=9.18N/m BeamWidth=2.47um
FringZ_off=13775Hz KflexureZ=6022N/m Kz/Kx=656
Fring15v=2187Hz Egap_off=1.84um
 This Egap_off is .36um below the expected 2.2um
 The conclusion is that the mover bumpers are touching the oxide covered skid pads on the stator when the electrode voltage is above 20v.

Motor Issues

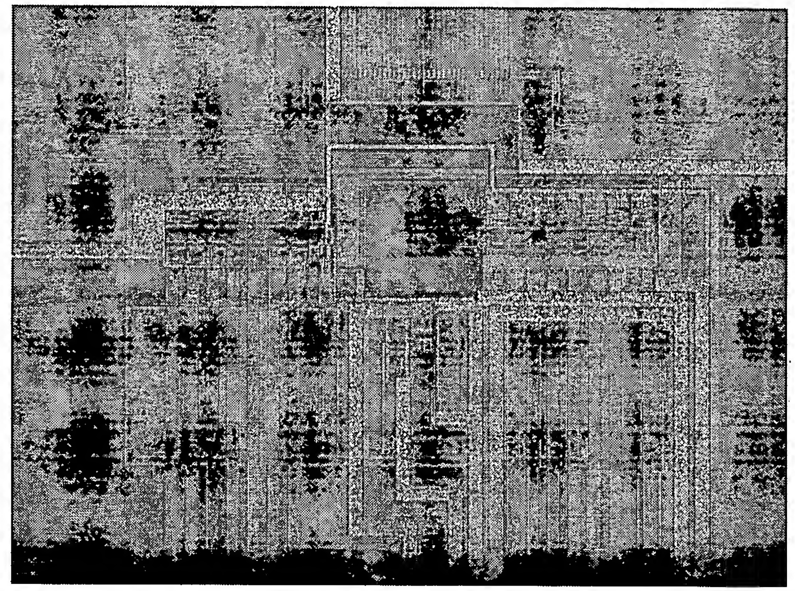
- Flexure trace delamination on 1st batch of RSAs
- Egap off .5um below target of 2.2um causing the bumper to rub.
- Bumper Stroke is .56um vs .8um
- High sensitivity of motor performance to EgapOff and Ve
- Large variation in motor parameters with stroke
- Unknown Z axis and torsional ringing in vacuum

Motor Driver Test Chip

Block Diagram

- Causes of high power consumption believed to be understood.
- Rev 2.0 and 2.1 silicon out with changes to reduce power
- 60v capable FETs are now available to allow a higher Ve and more margin (Xaccel and Ve adjustment). These FETs are 34% larger adding about 10% to the analog portion of the driver. The power will increase by 50v/40v=25% since the bias currents would remain the same.
- Rev1.0 used to drive Centurion RSA in coffin and wafer probe station.

2-Axis Motor Driver



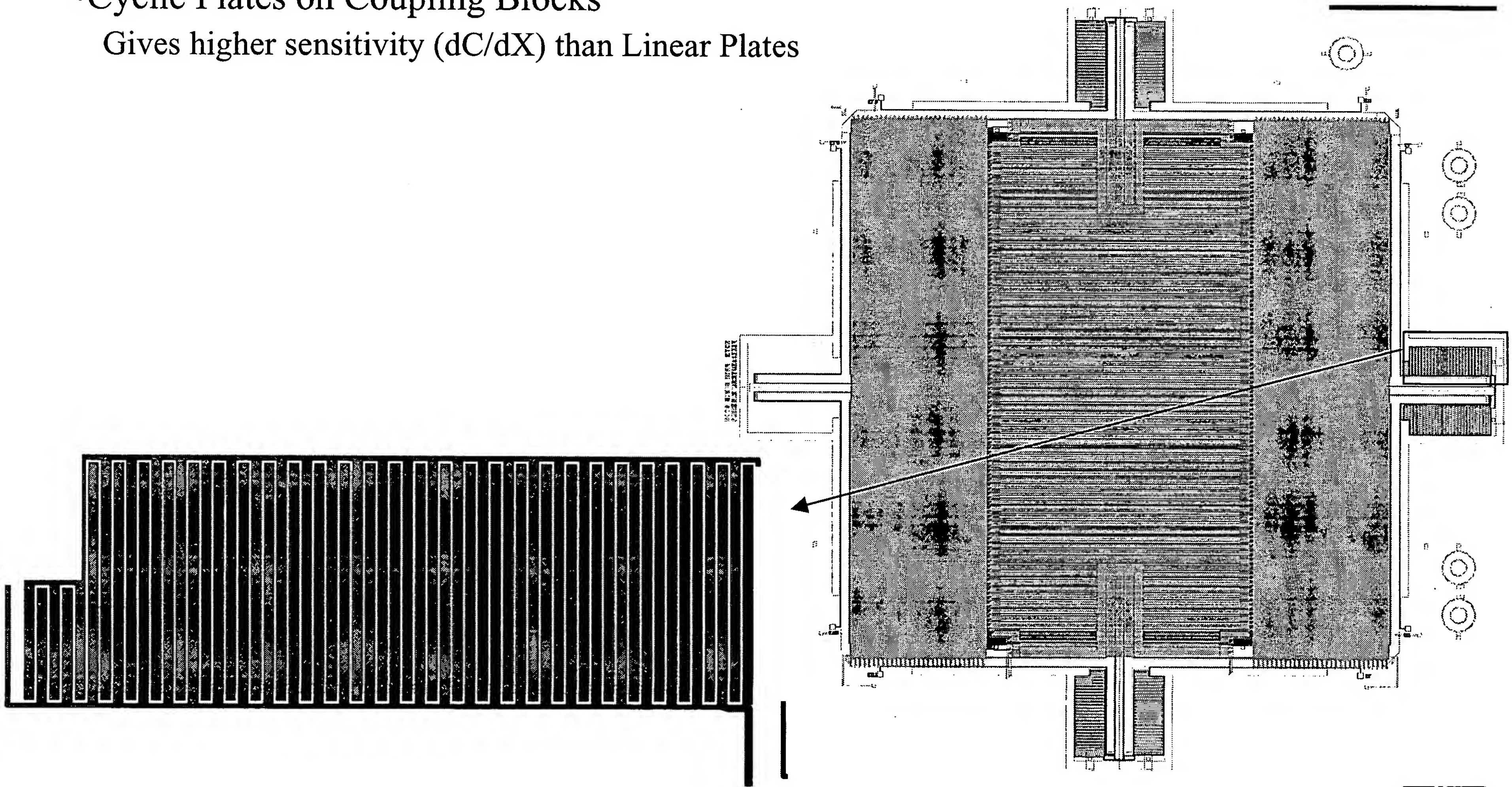
Issues:

- 40v Supply current is still higher than expected in the Rev2.1 chip.
  (Ive=100uA vs 40uA desired for 16 movers scanning IveRev1=165uA)

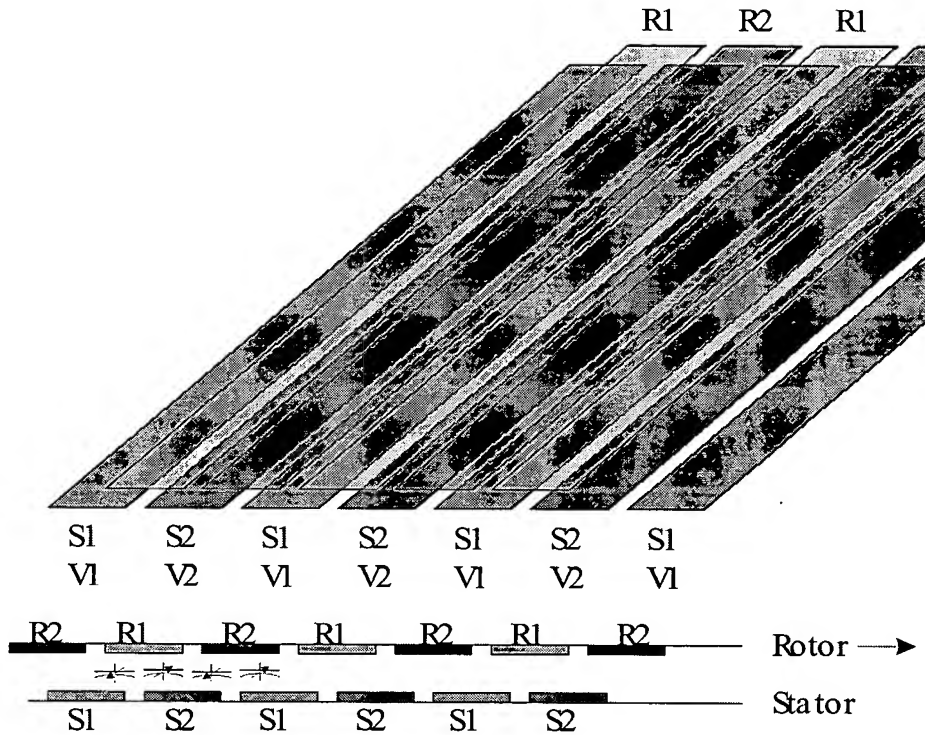
Capacitor Position Sense

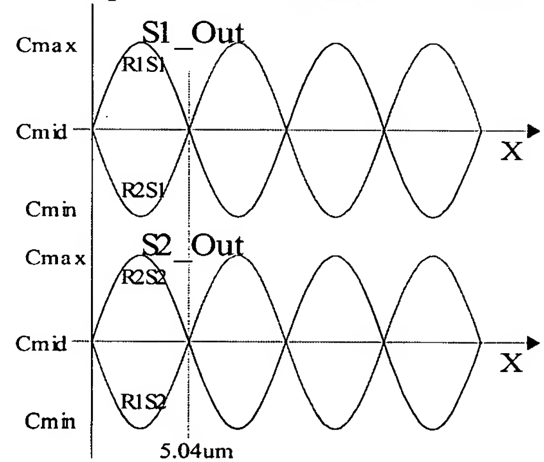
Block Diagram

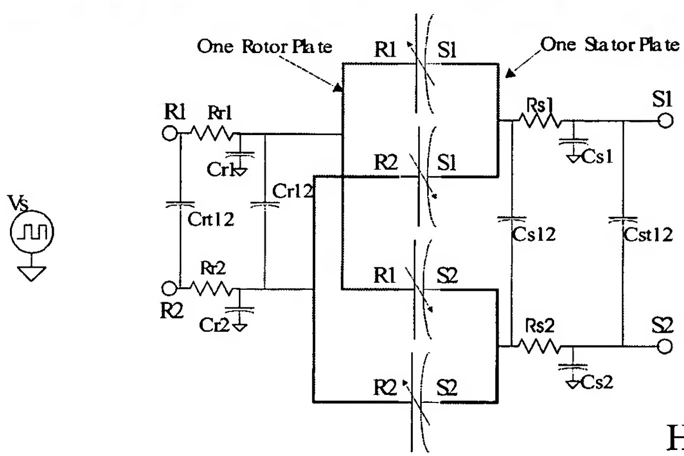
- Cyclic Plates on Coupling Blocks
  Gives higher sensitivity (dC/dX) than Linear Plates



Capacitor Plates







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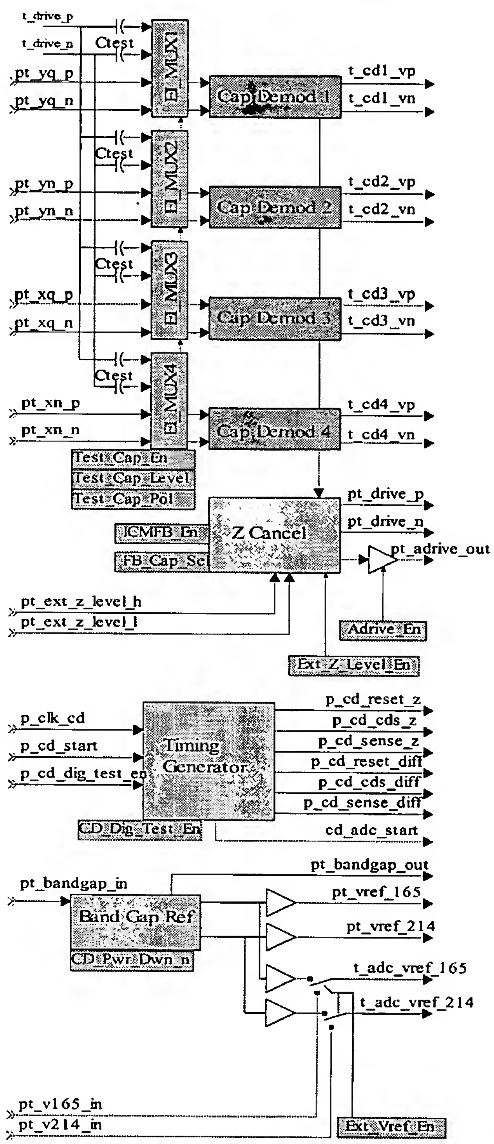
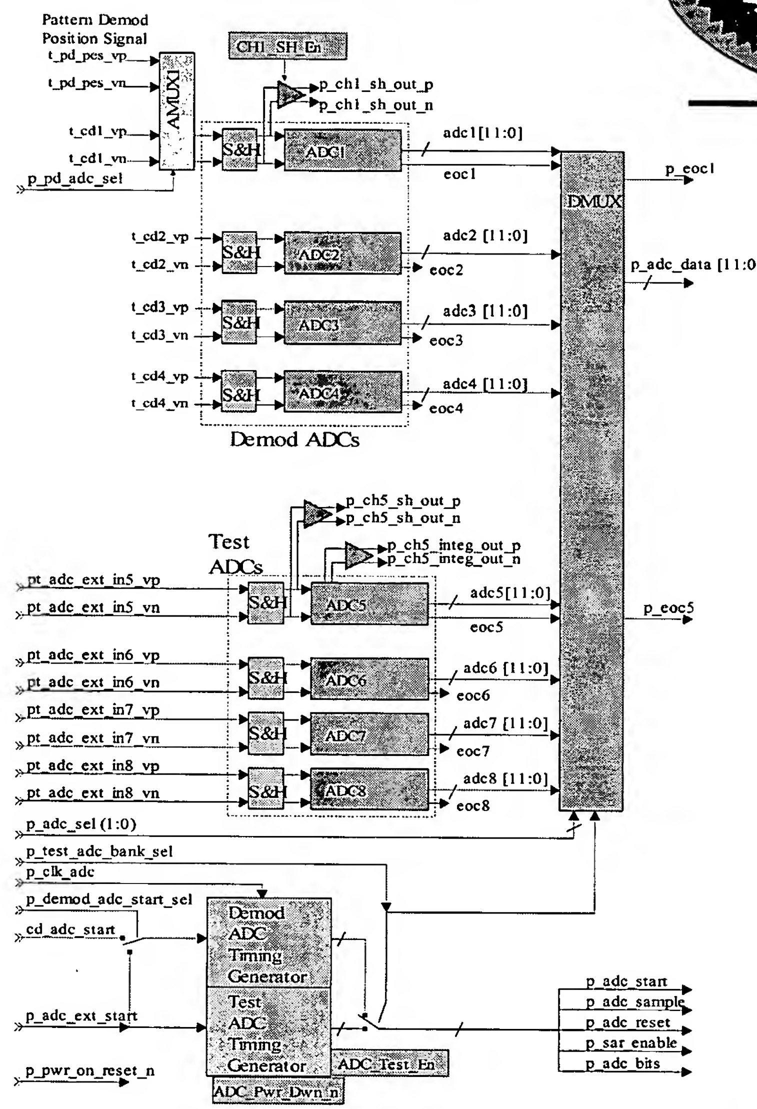
Capacitance Demodulator

Cap Demod Block Diagram



ADC Block Diagram



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Cap Sense Status

- Demodulator (CD) and ADC
  - -Test Chip evaluated with HPL mover and MockUp sensor
  - -Noise limited by ADC missing codes
  - -Metal fix to ADC (Rev1.1) did not eliminate missing codes
  - -Low gain observed on many CD channels may be due to MIM capacitors used in CD.
  - -Pattern demodulator induced noise linked to noise on floating pad ring.

- Issues:
  - Direct coupling from CD drive signals reducing gain and causing offsets.
  - Direct Coupling from Motor Electrode drive
    - - 31.6% coupling ratio
  - Long sense time due to large Rotor drive time constant
    - -Aluminum rotor traces required to lower resistance and time constant
  - Low Noise and Resolution Requirements
    - - 6nmpk noise
    - - 0.78nm resolution

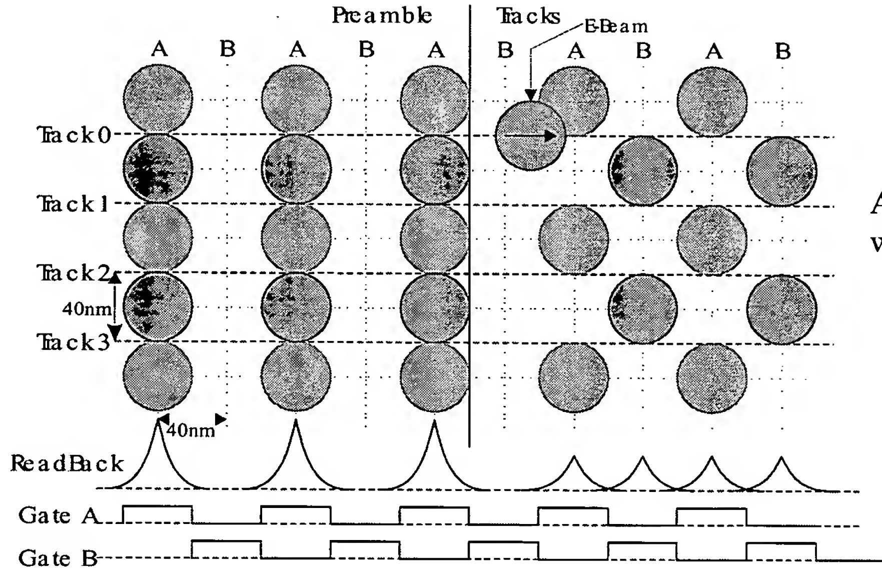
Servo Pattern

Block Diagram

- Pattern and Read-back Waveform
- Demodulator
- Pattern Write
- Impact of no Servo Pattern

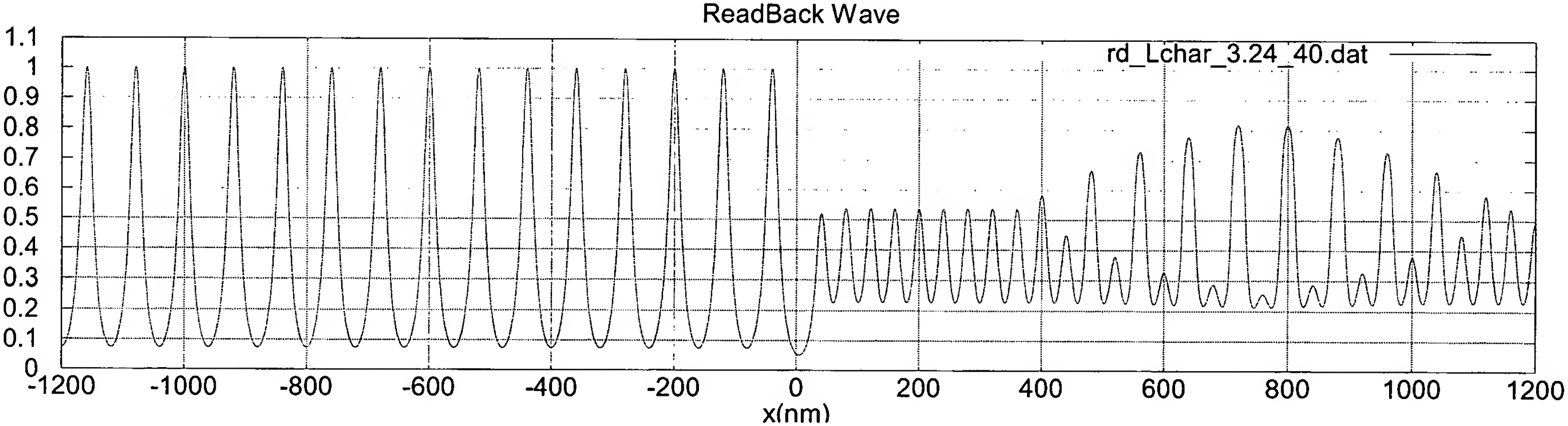
Pattern and Read-back

Servo Code Pattern

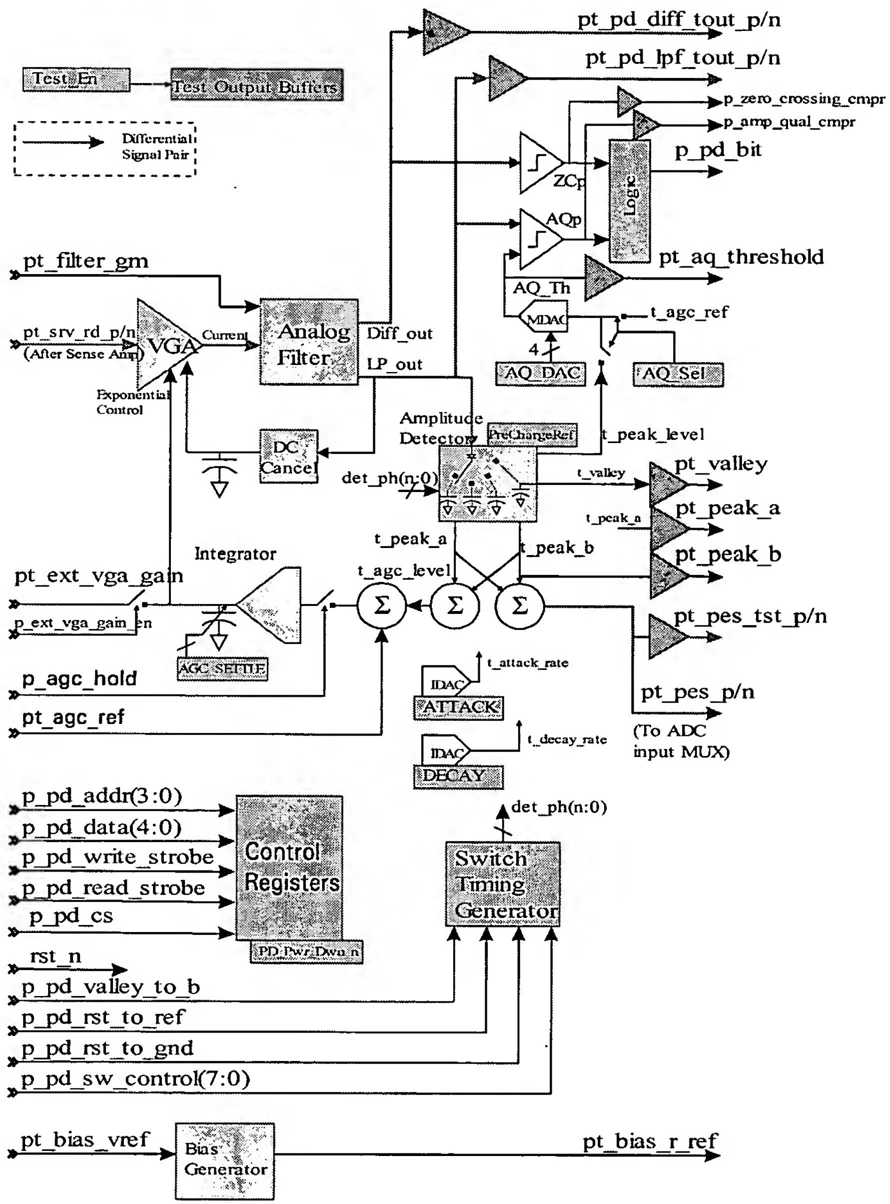


A-B Relative Amplitude gives position while pulses give timing

ReadBack Wave



Pattern Demodulator



•Input: Read-back waveform from servo patches

•Outputs: Analog Position signal (Across track)
Pulse timing ,1x clock signal (Down track)

•Test chip status

-Channel tested with arb waveforms

-Beginning design phase for Rev2

•Issues:

-Pulse qualify timing skew causes missing pulses

-Filter response error

-Low frequency noise

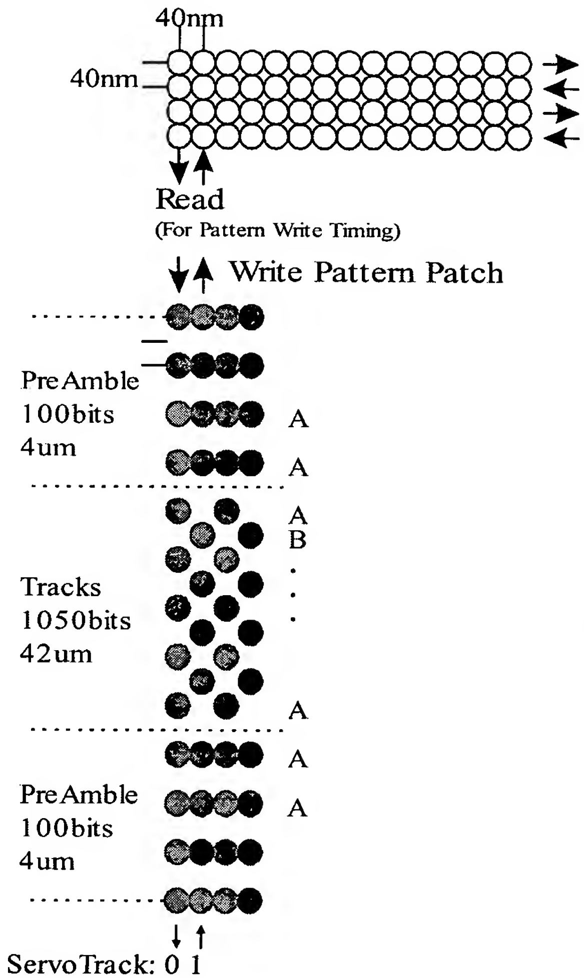
-2.7v operation

-Power Consumption 35mW 16ch

Pattern Write Process

Pattern Write Process

(May be done at low velocity)



Clock Track Patch
(Use a Data Patch)

- Assuming all 4 patches on all 16 movers are written simultaneously at 15mm/s:
  Write Time: 7sec
  Read Time: 28sec

Actual Write/Verify time estimate: 8-10min with spot tuning

Pattern Issues

- Small (+/-10%trk) linear range of servo pattern across track
- Low noise immunity of peak detectors vs integration or DFT methods.
- Writing and reading 40nm spots

Impact of No Servo Pattern

- Direct Coupling of motor drive signals to cap sensor position signal.

- Z axis sensitivity causing false cap position signals

- Cap Sensor drift, quantization and noise limits across track repeatability

  With an estimate of the signal noise of 500uV the total sensor noise estimate is 6nmpk. Assuming the sensor noise is 1/2 the off-track budget, this noise would limit the track pitch to 6nm*2/.1=120nm for a 10%trk off-track limit or 6nm*2/.15=80nm for a 15%trk off-track limit or 6nm*2/.2=60nm for a 20%trk off-track point.

- Cap Sensor drift, quantization and noise limits bit density

  The write clock was planned to be generated from the servo timing to allow accurate placement of data bits even if the velocity of the mover was off of the desired velocity. Without the servo pattern pulses to create this servo timing, a coarser servo clock would be generated from the cap position signal. This would require a larger bit cell and larger pads between sub-sectors down the track.

- Assuming no Direct Coupling or Z axis sensitivity:

  With a 60nm track pitch (20%trk off-track point) and no per-bit increase in the down the track density, the capacity would be 40/60*.903*=60% of the current 2GB capacity or 1.2GB.

- Show Calculations:

Calculations

Currently a track has:

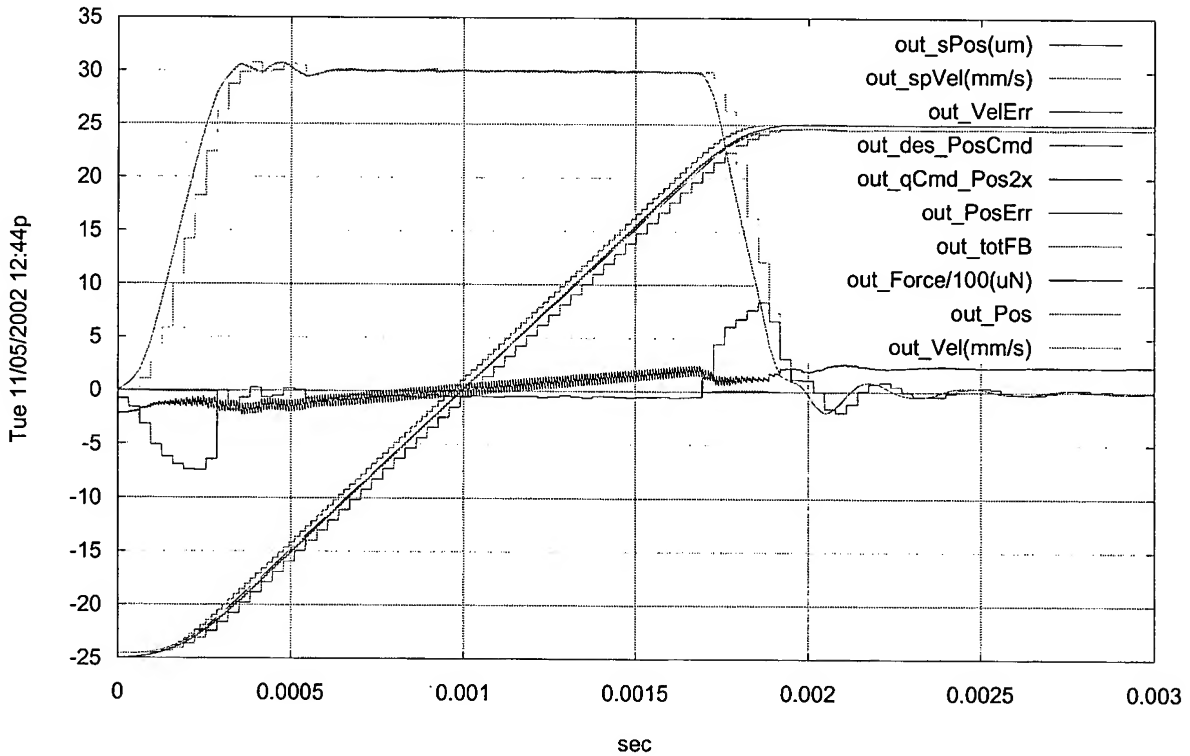
```
  (864db/track 892track/patch 112patch/cluster 15cluster/mover 16mover/module )
                                10.79MB/cluster .161GB/mover     2.59GB/module with
    ECC
 12 sub-sectors per track
   Data 9*12*8 = 864 bits (Data + ECC)
   PLL 6*8     = 48  bits
   Pad 1*12    = 12  bits
   Header 5*8  = 40  bits with correction byte
   Sync 1*8    = 8   bits
   Waste 2.5*8 = 20  bits
                 992  bits total

Overhead = 128 bits / 992 total bits

 Overhead = 128
 --------   ------ = 12.9% Current POR
   Data    = 992

changing the pad to 8bits for each sub-sector will increase the overhead to:

 Overhead = 212
 --------   ------ = 21.3% 780 data bits
   Data    = 992
The capacity is 780/864= 90.3% of the current POR design.
```

Digital Controller

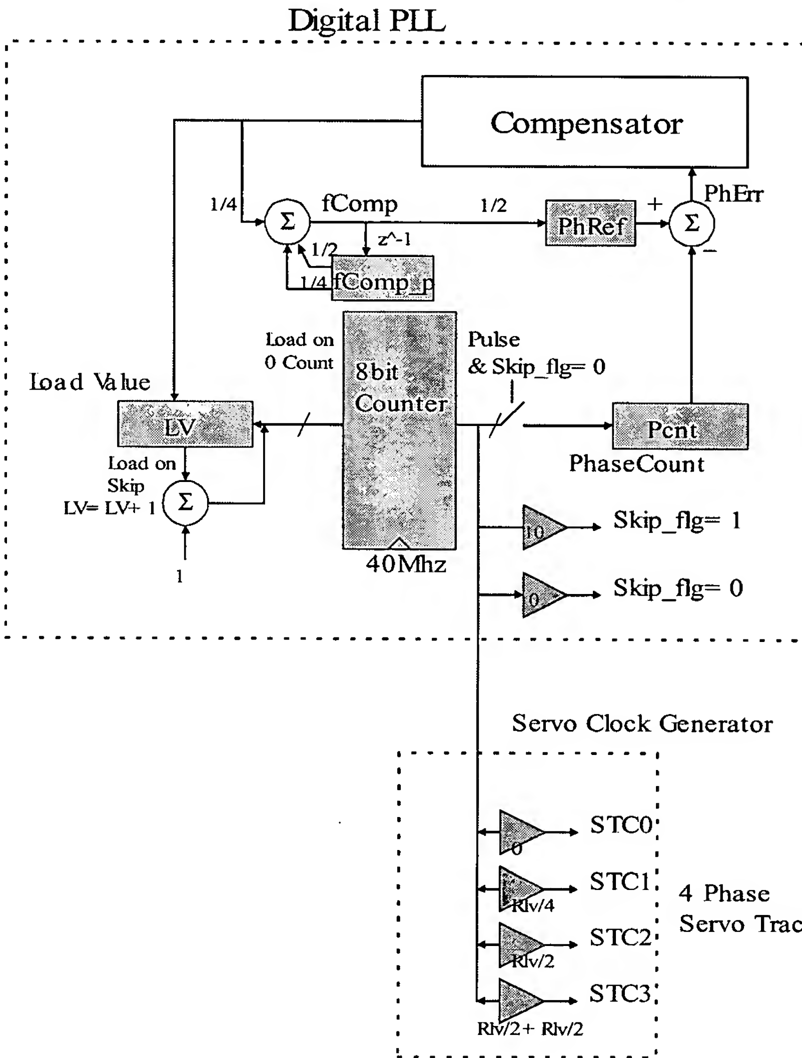
Simulated 50um Profiled Move

This simulation includes the 2x MotorDriver updates (17%more Ve power) and has the velocity and position loops closed.

FPk=365.1uN Kf=574N/m Ma=0.750mg Fo=4437 Qon=395 Kvel=0.015 Kpos=0.951 SkLen=50.00 FsSim=1.87Mhz

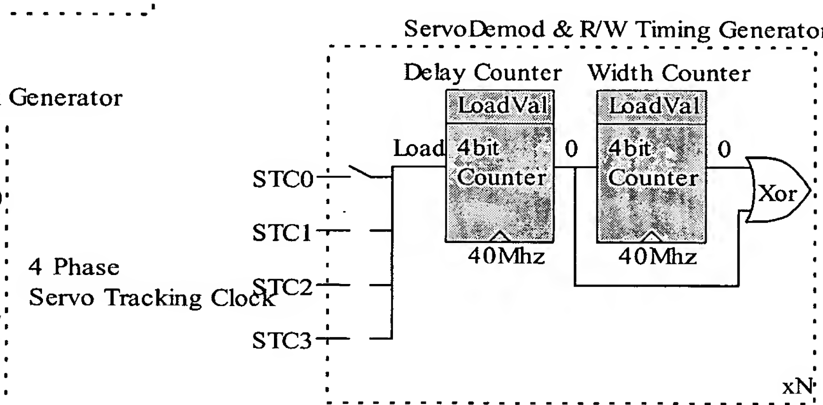


Digital PLL

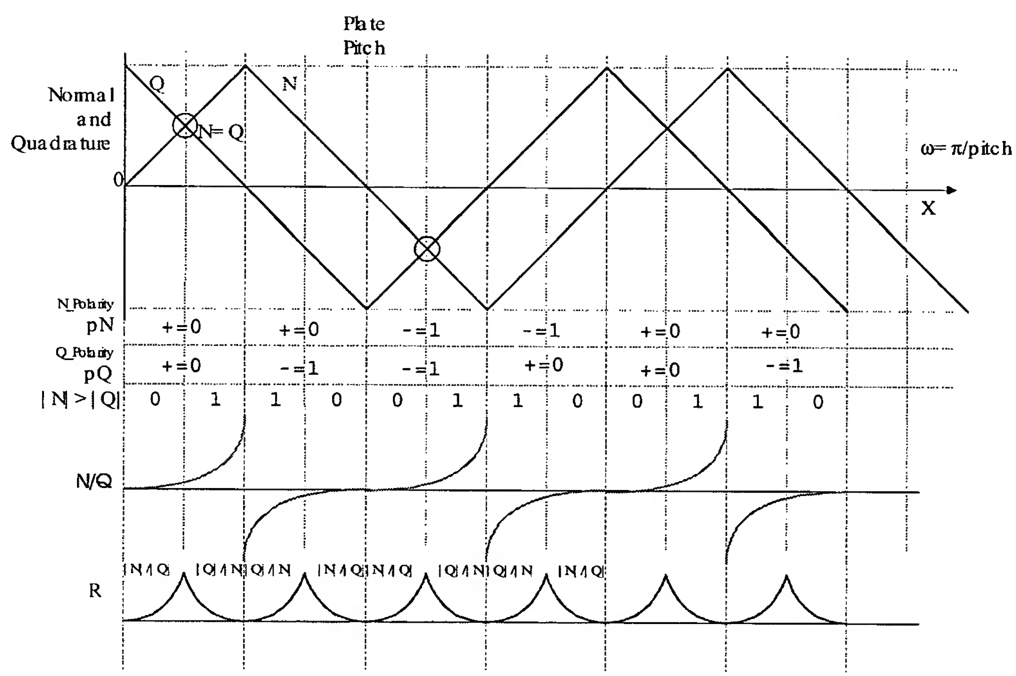


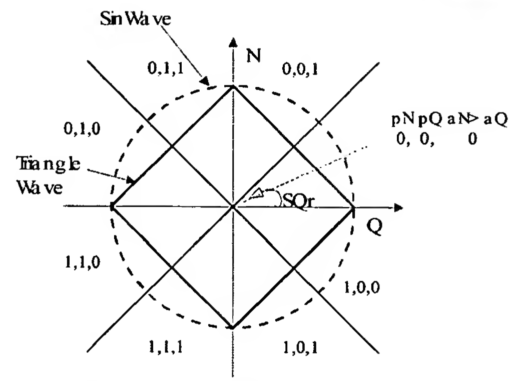
•Receives qualified pulses from Servo Pattern Demodulator

•Generates a 4-phase BitCell rate clock for Read & Write timing



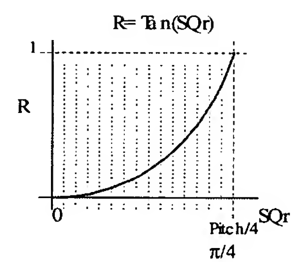
NQ Combiner

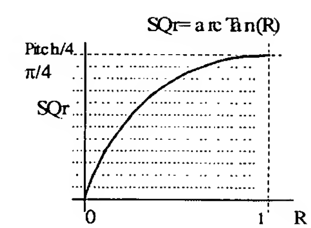




ArcTan Function Table

R	Angle	SQr
0	0	0
1	π/4	Pitch/4
inf	π/2	Pitch/2
(index)		(contents)





Shock and Vibration

- Current Data Sheet Specs:

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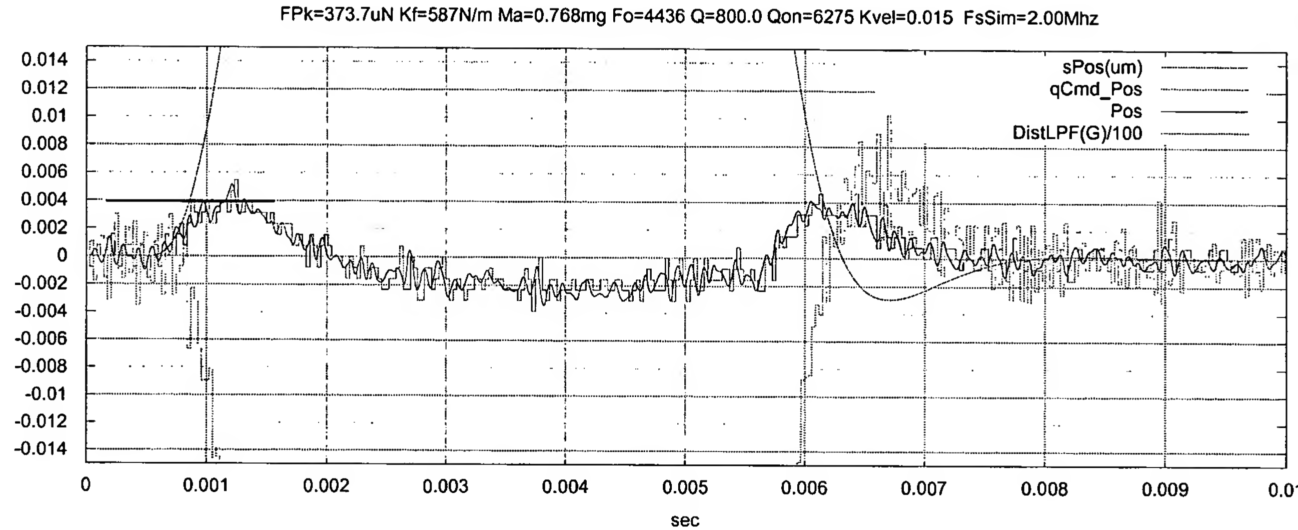
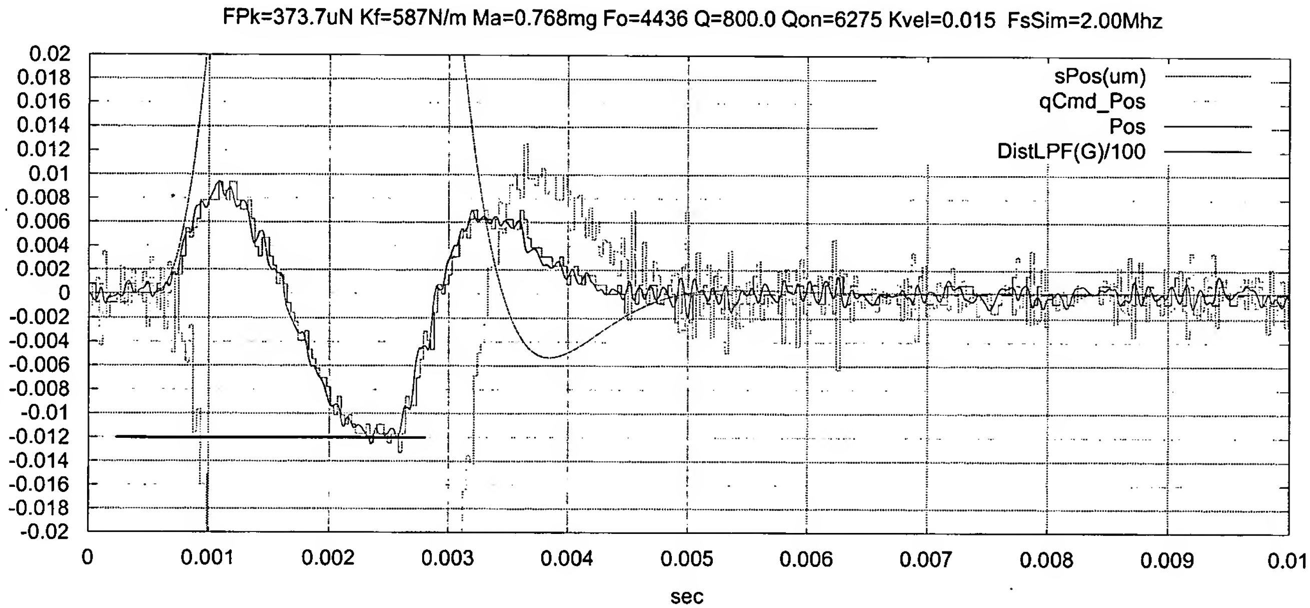
Shock Response

15G
5ms
500Hz
4nmpk

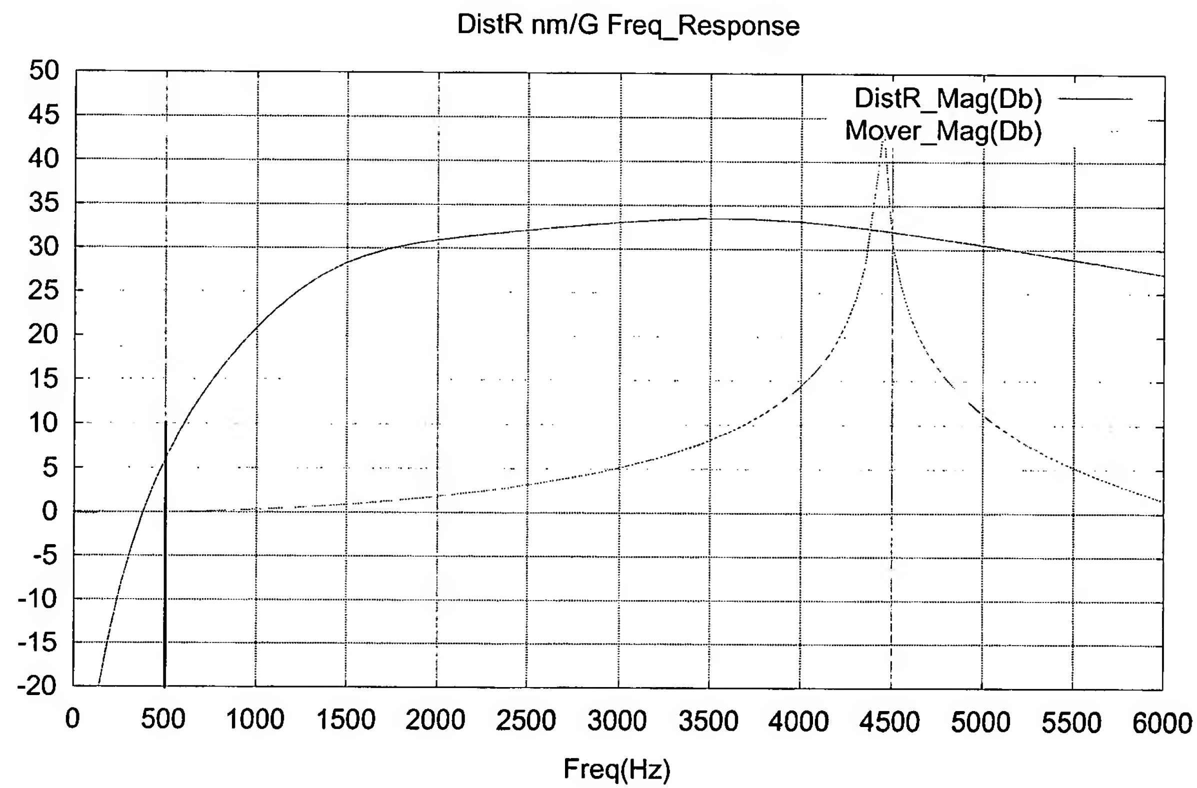


15G
2ms
500Hz
12nmpk



Vibration Response

- 12.8nm/G=22.1db sensitivity without servo
- 2nm/G @ 500Hz sensitivity with servo
- 0.82nmrms/G 5-500hz -> 2.4nm 3sigma peak off-track due to 1Grms Random



S&V Issues

- Soft mount (<500Hz) needed to meet 15G, 2ms shock spec.
- Random not specified in data sheet
- Remove "No Loss of Performance" from customer datasheet

Off-track Budget

- Main contributors to track miss-registration

  Factors which will cause a variation in the emitter to data track offset from data write to data read or cause data writes to encroach on adjacent previously written data tracks.

Show Budget

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Off-track Calculations

	11/7			
Track Mis-registration Sources				
Internal Sources				
			msf(0=RMS)	
Texpand	0.2150694	nm	0.5	Thermal Expansion
DBeamShift	1	nmpk	0.75	Data E-beam shift (Wrt_vs_Read,Time,Temperature,Age)
SBeamShift	1	nmpk	0.75	Servo E-beam shift (Wrt_vs_Read,Time,Temperature,Age)
MechCouple	1	nm	0.5	Mechanical Crosscoupling
RandVib	2	nmrms	0.5	Random (1Grms 0-500hz)
Offtrack	4.49409841	nm		
Disturbance				
SineVib	2	nm	1	Sine wave (1Gpkpk 500Hz)
RandVib	2	nmrms	0.5	Random (1Grms 0-500hz)
Thermal Expansion:				
Trange	65	DegC		
Si_CTE	2.60E-06	/K		
Distance	1800	um		
MissMatch	0.1	%	Is this reasonable?	
MissAlign	0.2150694	nm		

Back

Tune & Test Parameters

Tune:

- •Motor Electrode Voltage (Ve, 1 setting for all 16 movers)
- •Motor Force Constant (Kf_XY for each of 16 movers)
- •Capacitor Position Sensor (N-Q matching XY for 16 movers)
- •Media Contact Positions (XY, 16 movers)
- •Servo Patch Lens Voltage (write & read), Write Current Read Current (16 movers)

Test:

- •FringXYZ_off (16 movers)
  -verify flexures, vacuum
- •FringXYZ_on (16 movers)
  -verify electrostatic motor operation
- •Steps into wall for skitter (XY,16 movers)
  -peak motor force
- •Loop Gains XY (16 movers)
  -servo loop margins

Leigh Christian

From: ASHKANANI,PAT (HP-FtCollins,ex1)
Sent: Tuesday, February 18, 2003 10:09 AM
To: 'Kathryn Elseth'
Cc: FASEN,DON (HP-Boise,ex1)
Subject: RE: 10016512-1/H303.159.101

Importance: High

His email is don.fasen@hp.com.

Thanks,
Patricia Ashkanani
https://ecardfile.com/id/Patricia+Ashkanani

-----Original Message-----
From: Kathryn Elseth [mailto:kelseth@dbclaw.com]
Sent: Friday, February 14, 2003 1:01 PM
To: pat.ashkanani@hp.com
Subject: 10016512-1/H303.159.101

Dear Pat,
Can you plese verify the email for this inventor listed on the above-mentioned disclosure.
His name is Donald J. Fasen.
Thank you,

Kathryn Elseth
IP Legal Assistant
DICKE, BILLIG & CZAJA P.A.
Direct Dial: (612) 573-0667
Fax number (612) 573-2005
Email: kelseth@dbclaw.com

Servo Pattern Feasibility Study

The capability of the polymer media and the tip based write/read mechanism planned for CPS to produce a read-back signal with the characteristics needed for the high resolution position signal is unknown.

The servo pattern write feasibility study will investigate the capabilities of the CPS read-write channel (media and tips) to produce the required read-back signals.

The investigation will examine:

1) The ability to write the desired servo pattern on the media.
   To achieve the desired +/-25%track linear range from the servo pattern, the servo pattern pit size will need to be larger than the data pit size.
   Lengthening the write pulse duration and power is the method planned to generate these larger pits.
   The write investigation will write pits with various settings of these parameters and evaluate the effectiveness with AFM analysis of the pits.
   Interactions from adjacent tracks (to produce the A and B pattern) will also be evaluated.
   A post-DPE study will test the ability to write clock track timing on data patches based on the capacitance demodulator. The uniformity of the written timing tracks can be verified with the servo PLL and with AFM measurements.
   The clock track timing is then fed into the servo PLL to generate the write clock timing for writing the servo pattern in the servo patches.
   The uniformity of the servo pattern so written can be verified with the capacitance demodulator, servo PLL and AFM measurements.

2) The characteristics of the across track read-back from the written pits.
   In order to achieve the desired linear range, the read-back amplitude needs to have a linear relationship with the across track distance from the center of the written track.
   This investigation will record the read-back waveform over a +/-50%track range from the written center of a track. The effect of adjacent tracks will also be evaluated.

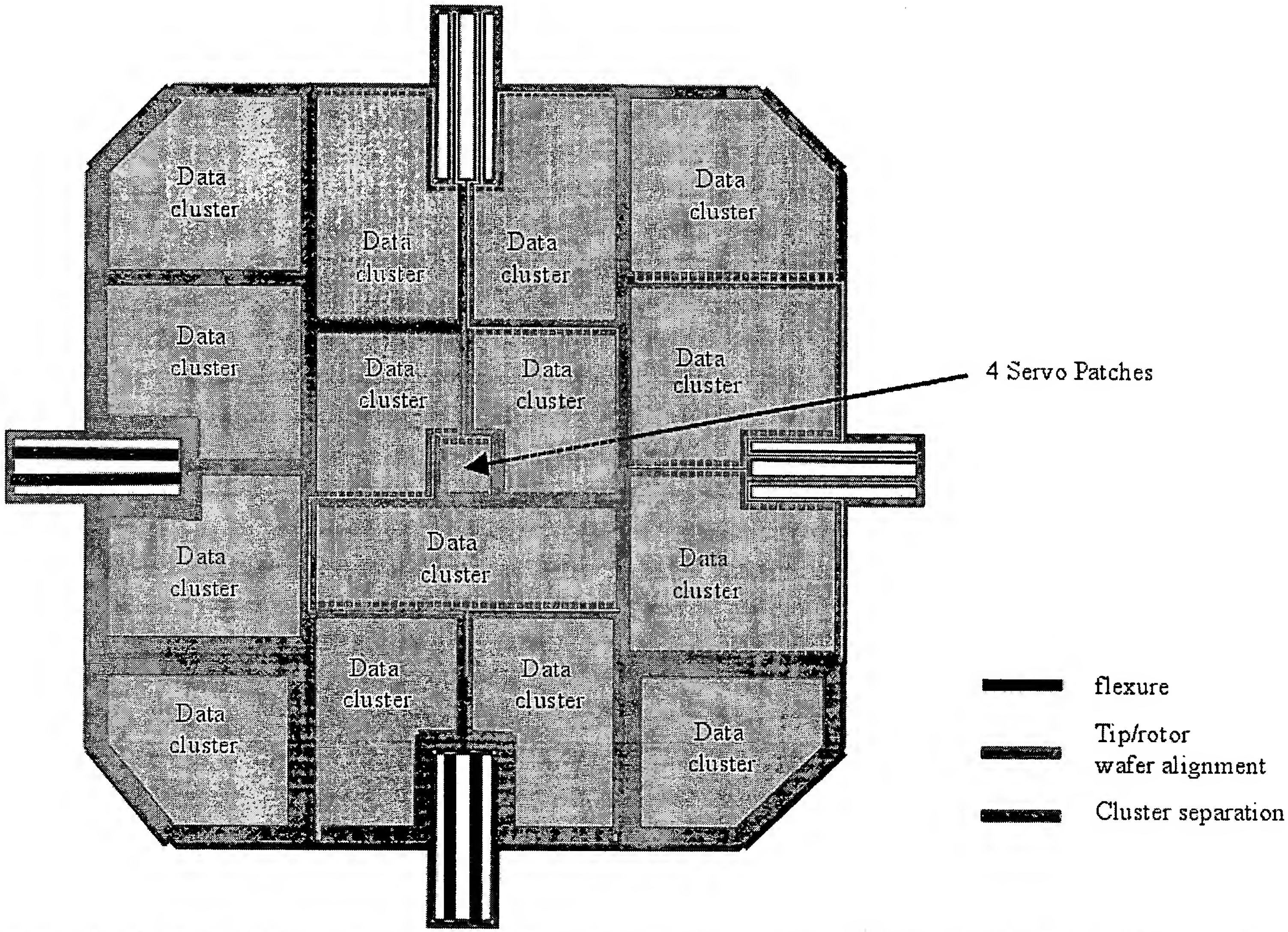
3) The ability of the Orca pattern demodulator electronics to process the read-back signal from the CPS channel and produce the required position signal and timing signals.
   The read-back waveforms captured in 2) can be used for this evaluation.

4) The life of the pre-written servo pattern.
   Since the servo pattern is written once in the factory and is then required to be reliably read for every data access (write or read) thereafter, the servo pattern must be not degrade with extended use.

Pattern Sensing

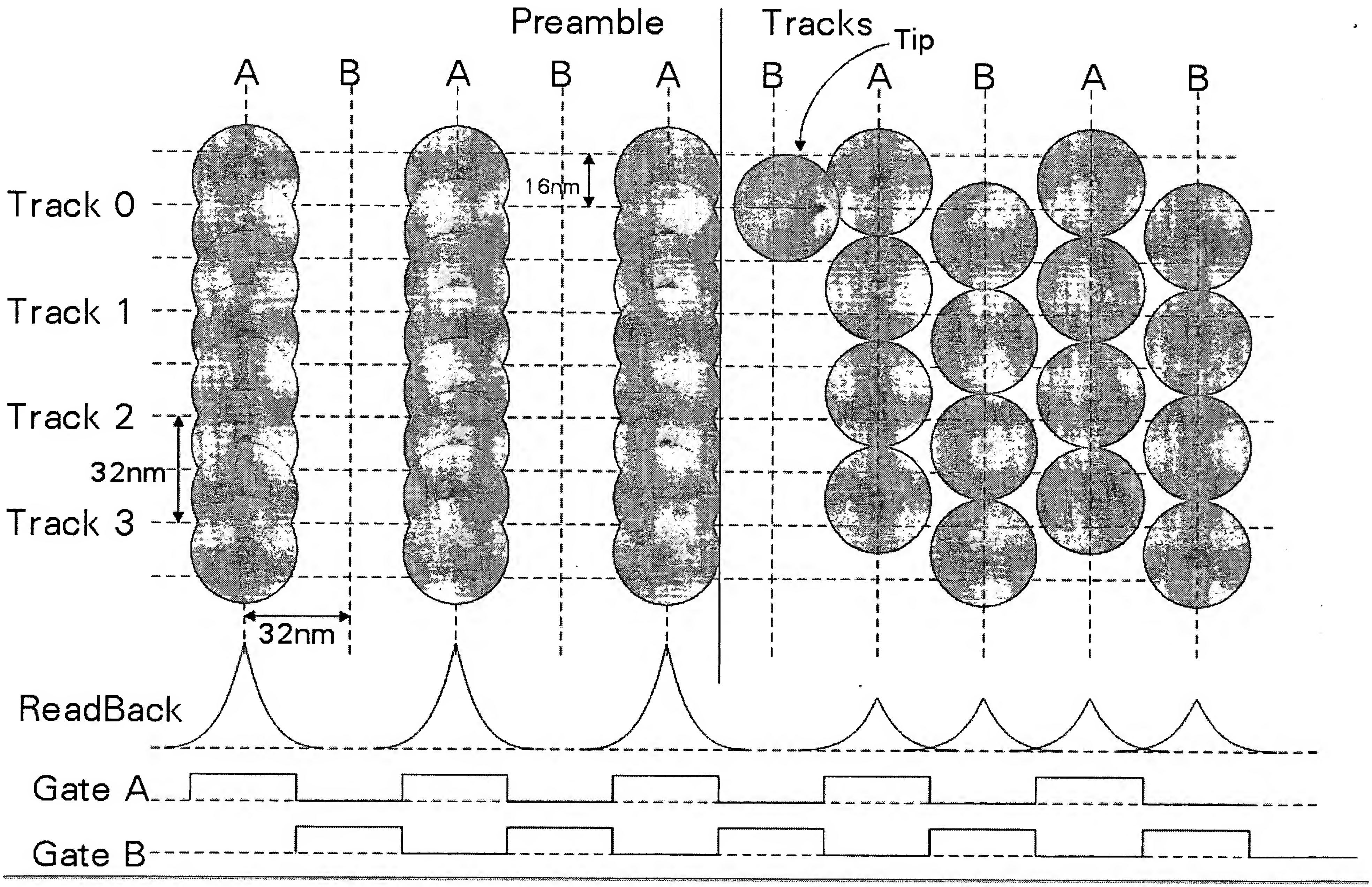
Updated: Wednesday, 02-Jul-2003 17:26:41 MDT

- Pattern Write Study
- Pattern Architectures
- ReadBack Waveforms
- Pattern Servo Code Disclosure



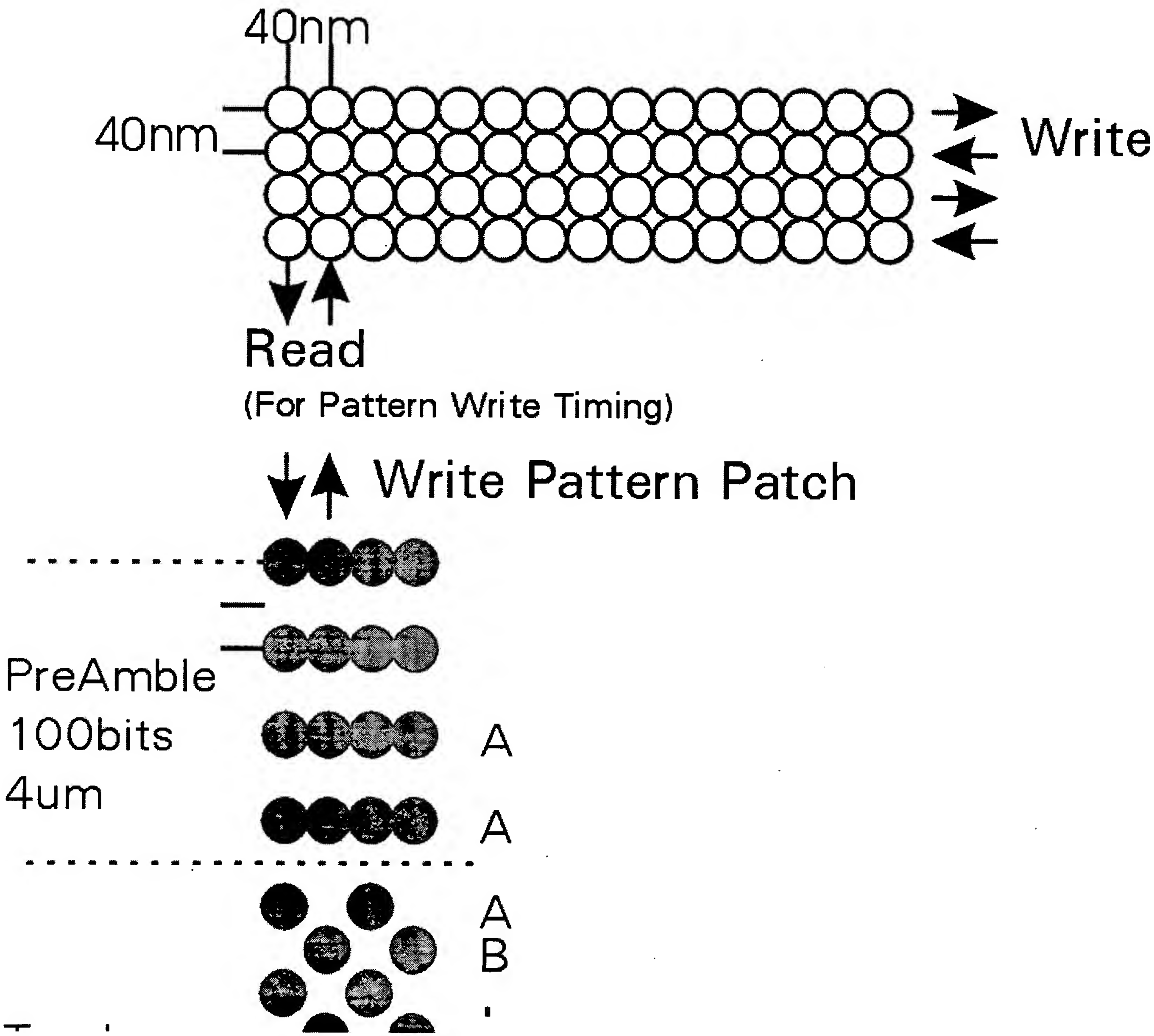
The proposed pattern allows for the narrow across track response of the 10nm deep, 10nm radius pits. The 2x density gives a +/-8nm position signal range.

2-Phase Servo Code Pattern
(2x Density ½ Range)



Pattern Write Process

(May be done at low velocity)



Clock Track F

(Use a Data Patc

Pattern Demodulator

Idealized pattern demodulator response to a +/-4nm movement. The Pes output is the A-B difference of integrated pulses.